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Manitou Stretch Area

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Report 284

B.R. Berger

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Foreword

The Precambrian rocks of the Lake of the Woods area were the focus of the earliest exploration for gold in northwestern Ontario in the early 1900s. This exploration discovered many occurrences and led to minor production of gold. The resurgence in exploration for gold in the late 1970s rekindled interest in the mineral potential of this area.

This report presents the results of detailed geological mapping undertaken in the Manitou Stretch area to improve the geological data base for mineral exploration and land use planning, and to stimulate mineral exploration by describing the geological setting of known mineralization. The study identified three structurally controlled environments that warrant further investigation for gold mineralization: within the Pipestone–Cameron–Manitou deformation zone, along contacts of large granitic batholiths, and within late, north-striking faults. Although gold has traditionally been the target of mineral explorationists in the area, the study identified felsic pyroclastic rocks and pervasively silicified rocks which hold good potential for base metal mineralization.

V.G. Milne
Director
Ontario Geological Survey

Abstract

The Manitou Stretch area is bounded by latitudes 49°07'30"N and 49°15'00"N and longitudes 92°56'15"W and 93°15'00"W. The area is approximately 300 km² and lies within the District of Kenora, northwestern Ontario.

The map area is underlain by Archean supracrustal rocks which are intruded by Archean granitoid batholiths and ultramafic to mafic dikes and sills. The supracrustal rocks were subdivided into litho-stratigraphic units and were correlated with the following groups.

1. The Wapageisi Lake group, which is composed of mafic tholeiitic basalts, is intercalated with the members of the Etta Lake formation, which is composed of intermediate epiclastic rocks, chert and volcanogenic metasedimentary rocks. The Wapageisi Lake group was deposited in a deep water environment distal to a volcanic vent.
2. The Blanchard Lake group is composed of mafic phaneritic flows and pillow breccia. It was deposited in a deep water environment distal to a volcanic vent.
3. The Upper Manitou Lake group is composed of intermediate and felsic pyroclastic and epiclastic rocks. It was deposited in a deep water environment and at least part of the group is proximal to a volcanic vent.
4. The Grant Lake group is composed of calc-alkalic, intermediate to mafic flows, hyaloclastites and pyroclastic rocks. The Grant Lake group was deposited in a shallow water to subaerial environment and is morphologically and mineralogically similar to modern island arc calc-alkalic volcanic sequences.

The Lawrence Lake Batholith intrudes the supracrustal rocks along the western margin of the map area and is a multi-phased granitoid intrusion composed of quartz diorite, tonalite, quartz monzonite and granodiorite. This intrusion is pre- to syntectonic in origin and some phases supplied magma to the Grant Lake group.

Granodiorite of the Irene–Eltrut Lakes complex intrudes the supracrustal rocks along the eastern margin of the map area and is syn- to late-tectonic in origin. The Bretz Lake stock is a satellite intrusion of the Irene–Eltrut Lakes complex that intrudes the supracrustal rocks along the southern boundary of the map area. It is compositionally zoned, having a monzonite to quartz monzonite rim and a granite core.

Ultramafic to mafic dikes and sills intrude the Grant Lake group in the Napanee–Harris lakes area and vary in composition from pyroxenite-peridotite to quartz diorite.

The most prominent structural feature in the map area is the Pipestone–Cameron–Manitou deformation zone, which is a regional structure extending from Lake of the Woods to Dinorwic, Ontario. The deformation zone effectively divides the map area into 2 domains and is characterized by numerous discrete shear zones which commonly anastomose. These shear zones have recorded a complex history of movement and progressively change orientation from east-northeast to northeast as one moves northward from the southern boundary of the map area. Vertical movement dominates the structural record along the entire length of the deformation zone; however, a minor component of sinistral movement overprints the vertical movement in shear zones from Grant Lake to Lower Manitou Lake. A second period of vertical movement occurred along the deformation zone along the southeast shore of Lower Manitou Lake.

The domain southeast of the deformation zone includes the Wapageisi Lake group, a homoclinal body with dominantly northeast-striking structures. The domain northwest of the deformation zone includes the Blanchard Lake group, the Upper Manitou Lake group and the Grant Lake group. Stratigraphy is folded in this domain and structures in both the supracrustal rocks and the Lawrence Lake Batholith are generally parallel to structures within the deformation zone.

North-striking, brittle to brittle-ductile faults sinistrally cut all rock types and are the youngest structural elements in the map area.

Gold occurs in 3 geological settings in the map area: 1) within shear zones and fractures of the Pipestone–Cameron–Manitou deformation zone where it is associated with carbonitization, sulphide mineralization and pervasive silicification; 2) within quartz veins in narrow shear zones outside of the Pipestone–Cameron–Manitou deformation zone; and 3) near the intersection of shear zones or faults with chert and pyroclastic rocks of the Etta Lake formation.

Copper mineralization occurs within structurally controlled quartz veins and is of limited economic importance. Other targets with greater base metal potential include the felsic pyroclastic deposits of the Upper Manitou Lake group and a pervasively silicified area within the Grant Lake group at Harris Lake.

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Résumé

Le secteur de Manitou Stretch est situé entre les latitudes 49°07'30"N et 49°15'00"N et les longitudes 92°56'15"W et 93°15'00"W. Le secteur couvre environ 300 km^2 et fait partie du district de Kenora dans le nord-ouest de l'Ontario.

Le secteur cartographié est représenté par des roches supracrustales archéennes qui sont intrudées par des batholites granitiques ainsi que des dykes et filons-couche ultramafiques à mafiques d'âge archéen. Les roches supracrustales ont été corrélées avec les groupes suivants:

Le groupe de Wapageisi Lake, composé de basaltes tholéiitiques, est intercalé avec des membres de la formation d'Etta Lake qui comprend des roches épiclastiques de composition intermédaire, du chert et des roches sédimentaires d'origine volcanique métamorphisées. Le groupe de Wapageisi Lake a été formé dans un milieu subaquatique profond loin d'une fissure volcanique.

Le groupe de Blanchard Lake est composé de coulées mafiques phanéritiques et de laves en coussins bréchifiées. Il a été formé dans un milieu subaquatique profond loin d'une fissure volcanique.

Le groupe de Upper Manitou Lake est composé de roches pyroclastiques et épiclastiques de composition intermédiaire à felsique. Il a été formé dans un milieu sub-aquatique profond et au moins une partie du groupe est proximale d'un orifice volcanicque.

Le groupe de Grant Lake est composé de coulées calco-alcalines de composition mafique à intermédiaire, de hyaloclastites et de roches pyroclastiques. Le groupe de Grant Lake s'est formé dans un milieu subaquatique peu profond à subaérien. Il est morphologiquement et minéralogiquement semblable aux séries volcaniques calco-alcalines des arcs insulaires modernes.

Le batholite de Lawrence Lake pénètre les roches supracrustales le long de la limite occidentale du secteur cartographié. Il représente une intrusion granitique polyphasée composée de diorite quartzique, de tonalite, de monzonite quartzique et de granodiorite. Cette intrusion est d'origine pré- à syn-tectonique et certaines des phases ont fourni du magma au groupe de Grant Lake.

Des granodiorites du complexe intrusif d'Irene-Eltrut Lakes pénètrent les roches supracrustales le long de la limite orientale du secteur cartographié. Ces granodiorites sont d'origine syn- à tardi-tectonique. Le massif de Bretz Lake est une intrusion satellite à la périphérie du complexe d'Irene-Eltrut Lakes, qui pénètre les roches supracrustales le long de la limite méridionale du secteur cartographié. Ce massif a une composition zonée présentant une bordure de monzonite à monzonite quartzique et un coeur de granite.

Des dykes et des filons-couche ultramafiques à mafiques intrudent le groupe de Grant Lake dans le secteur de Napanee Lake et Harris Lake. Leur composition varie de la pyroxénite-péridotite à de la diorite quartzique.

La structure la plus proéminante dans le secteur cartographié est la zone de déformation de Pipestone-Cameron-Manitou qui représente une structure régionale s'étirant de Lake of the Woods à Dinorwic, Ontario. Cette zone de déformation partage de façon nette le secteur cartographié en deux domaines et se caractérise par de nombreuses zones de cisaillement discrètes qui, souvent, s'anastomosent. Ces zones de cisaillement ont connu une histoire complexe quant au mouvement des roches. Elles changent d'orientation d'est-nord-est à nord-est au fur et à mesure que l'on se déplace vers le nord à partir de la limite méridionale du secteur cartographié. Le mouvement vertical domine l'évolution structurale sur toute la longueur de la zone de déformation. Cependant, une composante horizontale mineure avec un décrochement sénestre se superpose au mouvement vertical dans les zones de cisaillement s'étirant de Grant Lake à Lower Manitou Lake. Une deuxième phase de mouvement vertical a eu lieu le long de la zone de déformation le long de la rive sud-est de Lower Manitou Lake.

Le domaine au sud-est de la zone de déformation comprend le groupe de Wapageisi Lake, un ensemble homoclinal avec des structures orientées en grande partie vers le nord-est. Le domaine au nord-ouest de la zone de déformation comprend le groupe de Blanchard Lake et les groupes de Upper Manitou Lake et de Grant Lake. Dans ce domaine, la stratigraphie est plissée et les structures des roches supracrustales et celles du batholite de Lawrence Lake sont généralement parallèles aux structures présentes au sein de la zone de déformation.

Des failles méridiennes cassantes à cassantes-ductiles avec un décrochement sénestre recoupent tous les types de roches et représentent les éléments structuraux les plus jeunes dans le secteur cartographié.

Dans le secteur cartographié, l'or se trouve dans trois contextes géologiques: 1. au sein des zones de cisaillement et des fractures de la zone de déformation de Pipestone-Cameron-Manitou où il se trouve associé avec des roches carbonatisées, des minéralisations en sulfures et une silicification diffuse; 2. dans des veines de quartz contenues dans des zones de cisaillement étroites, en dehors de la zone de déformation de Pipestone-Cameron-Manitou; 3. près de l'intersection de zones de cisaillement ou de failles avec des cherts ou des roches pyroclastiques de la formation d'Etta Lake.

Une minéralisation cuprifère se trouve dans des veines de quartz associées avec des structures tectoniques mais cette minéralisation est peu importante du point de vue économique. D'autres cibles éventuelles pour l'exploration minière avec un potentiel en métaux de base plus important sont les unités de roches pyroclastiques du groupe de Upper Manitou Lake ainsi qu'une zone de silicification diffuse au sein du groupe de Grant Lake qui se trouve à Harris Lake.

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Precambrian Geology
Manitou Stretch Area

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Introduction

The Manitou Stretch area is bounded by latitudes 49°07′30″N and 49°15′00″N and by longitudes 92°56′15″W and 93°15′00″W (Figure 1). The area, approximately 300 km², was mapped at a scale of 1:15 840 to improve the geological data base and to provide an incentive for mineral exploration. The area can be reached by taking Highway 502, off Highway 11, and the Cedar Narrows logging road to Esox Lake (10 km south of the map area), and then by taking a boat from Esox Lake to Manitou Stretch. Aircraft based in Fort Frances, 43 km south, or Nestor Falls, 45 km west, provide alternative access to the area. Within the map area, numerous cleared and marked portages provide boat access to many lakes including Gates Lake, Grant Lake, Calder Lake, Syndicate Lake and Aronson Lake. Aircraft-supported fly camps were used to map the Harris Lake and Kahabeness Lake areas.

HISTORY OF EXPLORATION

There are no known economic mineral deposits within the map area; however, the Gaffney gold deposit is located 5 km to the northeast (Blackburn 1976) and the formerly producing Straw Lake Beach gold mine is located 8.5 km to the west (Edwards 1983). Coleman (1896) reported that exploration for gold resulted in the discovery of quartz veins and the excavation of shafts at Sairey Gamp Lake (now known as Napanee Lake). Thomson (1934) reported that gold exploration in the early 1900s resulted in the discovery of the Gold Standard occurrence on Neilson Lake. Exploration in the 1930s and 1940s resulted in the discovery of the Beehive, Gaffney and Straw Beach Lake gold deposits outside of the map area and the Gates Lake–Peep Bay gold showings within the map area. From 1983 to 1985, renewed interest in the Gaffney deposit sparked extensive exploration in the map area by several companies; no important new discoveries were made.

Exploration for base metals was carried out in the early 1970s by the Canadian Nickel Co. but no significant discoveries were made. Since then, there have been no filings for assessment work credit in base metal exploration.

In 1988, the Gates Lake and Peep Bay areas were staked by R. Fairservice, prospector, and optioned to Homestake Mineral Development Company Limited (Brian Christie, Homestake Mineral Development Company Limited, personal communication, 1988). A number of mining claims were in good standing in the Napanee Lake area at the time of writing (January 1989).

PREVIOUS GEOLOGICAL WORK

The earliest references to the geology of the map area are contained in maps by Lawson (1887) and McInnes

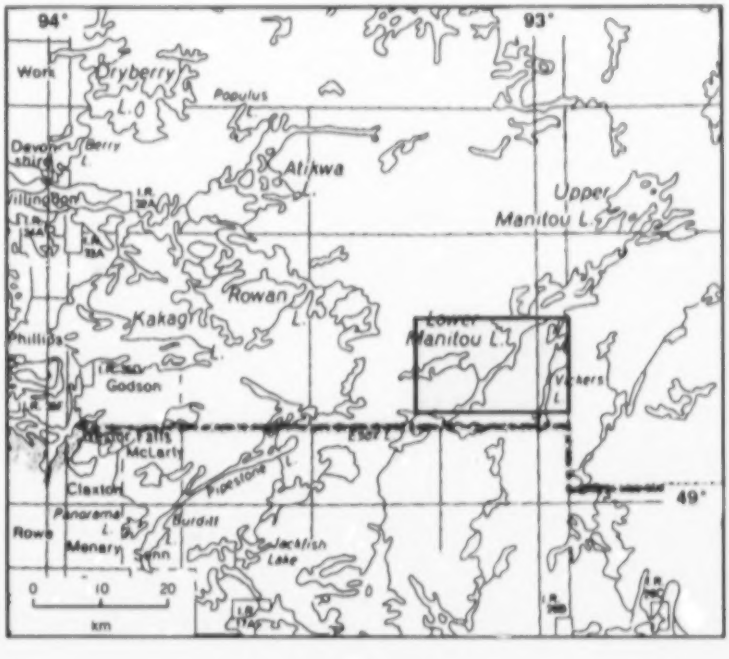

Figure 1. Key map showing location of the Manitou Stretch area, scale 1:1 584 000.

(1902). Coleman (1896) and Bow (1899, 1900) reported on the early exploration activities on gold properties, and Thomson (1934) mapped the area at a scale of 1:63 360 as part of the much larger Straw–Manitou lakes area. Blackburn (1973, 1976, 1982) mapped the Lower Manitou Lake area contiguous with the northeast part of the present area, at scales of 1:15 840 and 1:50 000. Edwards and Sutcliffe (1977) and Edwards (1983) mapped the Straw Lake area to the west at a scale of 1:15 840. In 1988, Smith and Stephenson (1988) mapped the Vista Lake area, situated immediately to the south at a scale of 1:15 840 . Information on the area has been compiled in Geological Data Inventory Folio 320 (Ontario Geological Survey 1986).

In 1961, an aeromagnetic survey was flown over the map area and the final maps were published at a scale of 1:63 360 (ODM–GSC 1961a, 1961b). An airborne electromagnetic and total-intensity magnetometer survey (Map 80477, Ontario Geological Survey 1980) covered the area around Aronson Lake. In 1988, the Geological Survey of Canada (GSC) released total-field and vertical-gradient aeromagnetic maps, at a scale of 1:50 000, that cover most of the map area (Geological Survey of Canada 1988a, 1988b).

Scientific studies by Trowell et al. (1980) and Blackburn et al. (1985) examine various aspects of stratigraphic correlation and geochemistry which apply to the map area. Davis et al. (1982), Davis et al. (1988), Davis and Edwards (1982, 1985), Edwards and Davis (1984) and Edwards (1985) used zircon U-Pb dating techniques to examine aspects of crustal evolution that pertain to the western Wabigoon Subprovince.

PRESENT SURVEY

The Manitou Stretch area was mapped at a scale of 1:15 840 during the 1988 field season. The mapping crew comprised the author, 1 senior assistant and 3 junior assistants. Standard pace and compass traverses, using 1:15 840-scale black and white, vertical aerial photographs for control, were carried out in conjunction with shoreline traverses to map the area. Traverses were spaced to provide coverage of the supracrustal rocks.Large areas underlain by granitic rocks in the northeastern part of the area were investigated only near the border with the supracrustal rocks. Almost all of the shoreline outcrops on the larger and more accessible lakes were mapped and areas of dense outcrop in economically or structurally important areas were mapped in detail.

The field data were plotted on acetate overlays that were taped to the aerial photographs. The data were then transferred to base maps prepared by the Cartography Section, Ontario Division of Lands, from maps of the Forest Resources Inventory, Ontario Ministry of Natural Resources.

PHYSIOGRAPHY

All waters in the map area eventually flow south into Rainy Lake which is part of the Arctic watershed. Drainage patterns are poorly developed and are locally controlled by bedrock structures and glacial features. Much of the area is dominated by rocky terrain and glacial deposits are thin to non-existent.

The map area is characterized by gentle relief, seldom exceeding 25 m. Outcrop density in the bush is relatively uniform, at 10% and 30%; along some of the lakes, shoreline outcrop density approaches 100%.

ACKNOWLEDGMENTS

D.S. Jeffrey capably served as senior assistant on this project and carried out independent mapping over approximately 50% of the area. P. Wilson, R. Shaver and B. Ansel provided competent assistance. P.M. Smith mapped the Vista Lake area contiguous to the south and several of his observations and conclusions are described in this report.

Logistical support, provided by the staff of the Resident Geologist's office, Kenora, is gratefully acknowledged.

General Geology

The Manitou Stretch area is underlain by Archean rocks of the Superior Province of the Canadian shield. Supracrustal rocks make up approximately 75% of the map area and are composed of: mafic, intermediate and felsic metavolcanic rocks; related subvolcanic intrusions composed of gabbro, quartz gabbro, feldspar and quartz-feldspar porphyries; and minor amounts of chemical and clastic metasedimentary rocks (Ayres et al. 1985). Felsic plutonic rocks intrude along the eastern and western boundaries of the supracrustal rocks and are composed of granodiorite, tonalite, quartz diorite, monzonite and granite. A distinctive suite of mafic to ultramafic dikes and sills locally intrude the supracrustal rocks (Table 1).

The supracrustal rocks in the map area were grouped into litho-stratigraphic groups based on morphology, composition and geographic distribution. Wherever possible, these groups were correlated with rock groups identified in adjacent areas (Figure 2). Several lithologic groups extend northeast of the Manitou Stretch area where they are correlated with the Wapageisi Lake group (including some members of the Etta Lake formation), the Blanchard Lake group and the Upper Manitou Lake group (Blackburn 1973, 1976, 1979, 1982).

Metavolcanic rocks mapped in the Straw Lake area, located immediately to the west of the map area (Edwards and Sutcliffe 1977, Edwards 1983), extend into the map area where they are referred as the Grant Lake group by the author.

Smith and Stephenson (1988) mapped the Vista Lake area, which is contiguous with the Manitou Stretch area to the south, during the 1988 field season. Many of the rocks units described in this report also occur in the Vista Lake area and readers are referred to the publication by these authors for further details.

Much of the description in this section on the general geology is in table form; emphasis is placed on describing the similarities of, and the differences between, su-

Table 1. Lithologic units of the Manitou Stretch area.

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT

Lake, stream, and wetland deposits

PLEISTOCENE

Sand and gravel

UNCONFORMITY

PRECAMBRIAN

ARCHEAN

NEOARCHEAN

Metamorphosed Felsic Intrusions

Granodiorite, tonalite, quartz monzonite, quartz diorite, migmatite, diorite, monzonite, granite, pegmatite, aplite

Mafic Intrusions

Lamprophyre dikes, gabbro, diorite, quartz gabbro, quartz diorite, plagioclase-phyric gabbro, pyroxenite, peridotite, pyroxenitic gabbro, granophyric gabbro, schist

Clastic and Chemical Metasedimentary Rocks

Chert, siltstone, sandstone, schist

Felsic Metavolcanic Rocks

Tuff, crystal tuff, lapilli tuff, tuff breccia, breccia, schist, felsite dikes, quartz-feldspar porphyry, quartz porphyry

Intermediate to Mafic Metavolcanic Rocks

Massive and pillowed flows, pillow breccia and hyaloclastite, tuff, crystal tuff, crystal lapilli tuff, lapilli tuff, tuff breccia, breccia, chlorite $\pm$ sericite schist, chlorite-sericite-carbonate schist, biotite-bearing amphibolite, biotite-bearing feldspar porphyry

Mafic Metavolcanic Rocks

Massive, plagioclase-phyric and pillowed flows, pillow breccia, autoclastic breccia, hyaloclastite, tuff, lapilli tuff, tuff breccia, breccia, chlorite schist, chlorite-carbonate schist, hornblende $\pm$ biotite-bearing amphibolite, basaltic dikes, feldspar porphyry

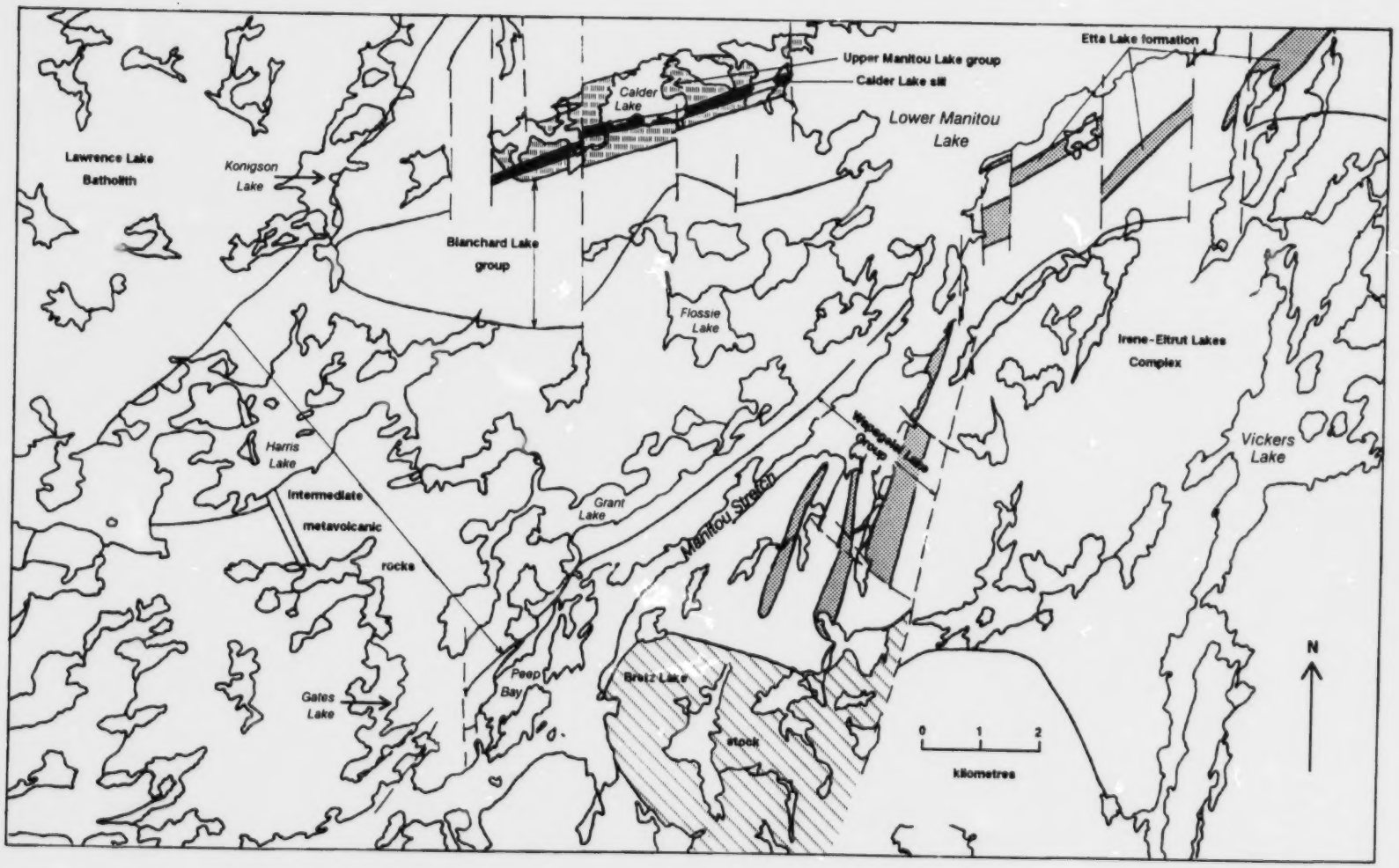

Figure 2. Stratigraphic correlation map, Manitou Stretch area.

pracrustal groups and on interpreting depositional environments.

The most prominent structural feature in the map area is a deformation zone composed of several discrete shear zones, fractures and faults. This is a regional structure extending from Lake of the Woods to Dinorwic, Ontario, and is named the Pipestone–Cameron–Manitou deformation zone in this report.

Most of the supracrustal rocks mapped contain metamorphic mineral assemblages compatible with lower greenschist facies metamorphism (Winkler 1979). Surrounding the granitoid batholiths are upper greenschist facies to lower amphibolite facies contact metamorphic aureoles.

A brief summary outlining some of the regional implications for the western Wabigoon Subprovince is presented.

NEOARCHEAN

Mafic Metavolcanic Rocks

Mafic metavolcanic rocks underlie approximately 25% of the map area and are the predominant rocks of the Wapageisi Lake group and the Blanchard Lake group.

WAPAGEISI LAKE GROUP

Mafic metavolcanic rocks that are correlated with the Wapageisi Lake group (Blackburn 1976, 1982) form part of a continuous group of rocks up to 3.5 km thick that extend for approximately 17 km along, and east of, Manitou Stretch and southeast of Lower Manitou Lake. These rocks extend southeast into the Vista Lake area (Smith and Stephenson 1988) and northeast of the map area. Mafic metavolcanic rocks south of Kahabeness Lake extend into the Vista Lake area, and based on morphology and composition, are also correlated with the Wapageisi Lake group.

Massive, plagioclase-phyric and pillowed mafic flows are the major rock types in the Wapageisi Lake group. Macroscopic and microscopic features are described in Table 2. These flows are most likely to be fine grained, massive or pillowed, and nonvesicular. Plagioclase phenocrysts, where present, are generally euhedral and small, and comprise less than 25% of the rock. Minor mafic tuff and pillow breccia units (along with abundant, reworked, intermediate epiclastic and chert deposits of the Etta Lake formation) are interbedded with Wapageisi Lake group mafic flows. Where mafic rocks are sheared within the Pipestone–Cameron–Manitou deformation zone, chlorite or chlorite-carbonate schists are developed. Recognition of the protolith is difficult as these are fine grained, indurated to fissile rocks. Schists that contain iron carbonate weather brown to red-brown , generally contain minor amounts of disseminated pyrite and locally contain geochemically anomalous amounts of gold.

Mafic amphibolite is developed in a contact metamorphic aureole that is up to 800 m wide around the Irene–Eltrut Lakes complex. Mafic amphibolite is characterized by a black weathered surface, a fine-grained to felty hornfelsic texture, and secondary epidote stringers and veins. Blue-green amphibole characteristically occurs in thin section and chlorite is absent or minor.

The general absence of vesicles in the mafic flows indicates that the Wapageisi Lake group was most probably deposited in a deep water environment distal to a volcanic source (Easton and Johns 1986).

BLANCHARD LAKE GROUP

A second sequence of predominantly mafic metavolcanic rocks up to 2.5 km thick extends west from Lower Manitou Lake along the northern boundary of the map area for approximately 7 km. These rocks are correlated with those of the Blanchard Lake group that are found northeast of the map area (Blackburn 1976, 1982). Flows of the Blanchard Lake group are described in Table 2.

The Blanchard Lake group is mostly composed of non-vesicular, phaneritic to gabbroic-textured flows with subordinate plagioclase-phyric flows and minor pillowed flows. Plagioclase phenocrysts in plagioclase-phyric flows are anhedral to glomeroporphyritic, and comprise 10% to 50% of the flow. Along the north shore of Lower Manitou Lake, pillow breccia units commonly accompany the flows and display features such as well-developed isolated pillows, lava ribbons and chilled fragments that are typical of classical pillow breccias (Carlisle 1963). Intermediate and mafic tuff units are only locally present and coarser pyroclastic rocks are absent. Chlorite and chlorite-carbonate schists occur only in the Pipestone–Cameron–Manitou deformation zone near Lower Manitou Lake. Black-weathering amphibolite, which contains blue-green amphibole and less commonly biotite, occurs west and southwest of Syndicate Lake and is locally intruded by granitic pegmatite and aplite dikes related to the Lawrence Lake Batholith.

Mafic feldspar porphyry contains 5% to 50%, white to green, 1 to 5 mm equant feldspar grains in a fine-grained black matrix that does not contain biotite.

The feldspar crystals are probably of metamorphic origin, as these rocks only occur within the contact metamorphic aureole of the Lawrence Lake Batholith west of Syndicate Lake.

The lack of vesicles in rocks of the Blanchard Lake group, combined with the predominance of phaneritic flows, suggests that thick accumulations of mafic lava developed rapidly in a deep water environment (Easton and Johns 1986).

GRANT LAKE GROUP

Mafic metavolcanic rocks are subordinate within the Grant Lake group where they occur as individual units a few metres wide or as a series of units up to 1.5 km thick, e.g., at Harris Lake. These units are commonly interlayered with intermediate flows and pyroclastic-epiclastic rocks, and extend less than 1 km along strike.

Table 2. Description of mafic and intermediate metavolcanic flows.

Wapageisi Lake group

Map units:	1a, b, c
Field names:	metabasalts, plagioclase–phyric flows, pillowed flows
Location:	southeast side of Lower Manitou Lake extending southwest along Manitou Stretch
Colour:	fresh surface is dark green to green; weathered surface is dark green to black
Grain size:	0.25 to 5 mm recrystallized groundmass; 5 mm to 1.5 cm white to green, euhedral to anhedral plagioclase phenocrysts
Texture:	commonly equigranular; less commonly phaneritic, locally plagioclase–phyric, porphyritic
Morphology:	volumetrically, massive flows are greater than porphyritic flows which are greater than pillowed flows; pillows average 30–50 cm by 50 –100 cm in size with very little interpillow material; few vesicles and/or amygdules with a maximum diameter of 5 mm
Related rocks:	minor mafic tuff; abundant intermediate tuff and lapilli tuff interbedded with chert; minor pillow breccia

Modal mineralogy: (estimated) n = 4

quartz	0% to 10%	
plagioclase	0% to 25%	$An_{?}$
epidote	5% to 35%	
amphibole	25% to 75%	
chlorite	10% to 75%	
carbonate	0%	
sericite	0%	
other	trace to 10%	pyrite, magnetite, titanite, ilmenite

Blanchard Lake group

Map units:	1a, b, c
Field names:	metabasalts, plagioclase–phyric flows, pillowed flows
Location:	north boundary of map area extending south of Calder Lake
Colour:	fresh surface is green to green–grey; weathered surface is dark green to black
Grain size:	0.25 to 5 mm partially recrystallized groundmass; 5 mm to 5 cm white, anhedral plagioclase phenocrysts, commonly glomeroporphyritic
Texture:	commonly phanertic, less commonly plagioclase–phyric or fine grained; porphyritic
Morphology:	volumetrically, massive flows are greater than porphyritic flows which are very much greater than pillowed flows; pillows average 50 by 70 cm in size with very little interpillow material; no vesicles and/or amygdules
Related rocks:	pillow breccia is common along the northern part of the sequence; minor interbedded mafic and intermediate tuff; locally gabbro and quartz gabbro sills

Modal mineralogy: (estimated) n = 4

quartz	0% to 5%	
plagioclase	10% to 40%	An_{38-70}
epidote	15% to 55%	
amphibole	15% to 60%	
chlorite	5% to 25%	
carbonate	0% to 5%	
sericite	0%	
other	0% to 5%	titanite, ilmenite, magnetite

Grant Lake group

Map units:	2a, b; 1a, c
Field names:	metabasalts, meta–andesites, metadacites, pillowed flows
Location:	western boundary of the map area extending northeast to Lower Manitou Lake
Colour:	fresh surface is blue–green, grey, grey–green; weathered surface is green, blue–green, grey
Grain size:	0.1 to 1 mm groundmass; 1 mm to 1 cm euhedral to anhedral plagioclase and/or amphibole phenocrysts
Texture:	most commonly porphyritic; commonly equigranular; locally phaneritic
Morphology:	volumetrically, porphyritic flows are slightly greater than pillowed flows which are very much greater than massive flows; pillows vary in size from 50–100 cm by 50–1000 cm; there is a great deal of interpillow material; abundant, large (1–5 cm) vesicles and amygdules
Related rocks:	abundant pillow breccia and hyaloclastite; abundant intermediate pyroclastic deposits

Modal mineralogy: (estimated) n = 17

quartz	5% to 25%	
plagioclase	10% to 50%	An_{27-32}
epidote	0% to 60%	
amphibole	0% to 25%	
chlorite	0% to 40%	
carbonate	0% to 25%	
sericite	0% to 20%	
other	0% to 55%	titanite, pyrite, biotite

Mafic flows of the Grant Lake group are massive, weather green to dark green and are green on the fresh surface. They are characterized by the absence of the plagioclase and amphibole phenocrysts which are common in the intermediate flows. Mafic pyroclastic deposits composed of tuff, lapilli tuff and tuff breccia contain white to green feldspathic fragments in a dark green tuffaceous matrix, whereas the matrix of intermediate pyroclastic rocks is blue-green to grey, tuff and crystal tuff. In several places along Manitou Stretch and in the central part of Gates Lake, there is no clear distinction between mafic and intermediate rocks and these rocks were designated as transitional (i.e., coded 1a/2 or 2a/1 on the map face).

Black weathering, fine-grained basaltic dikes up to 1.5 m wide are common in the Harris Lake area where they intrude silicified intermediate pyroclastic rocks. These dikes consistently strike east-northeast and have not been affected by the earlier silicification (*see* "Alteration").

Intermediate to Mafic Metavolcanic Rocks

Intermediate to mafic metavolcanic rocks underlie approximately 45% of the map area and are a significant component of 3 litho-stratigraphic groups, namely; the Grant Lake group, the Etta Lake formation of the Wapageisi Lake group and the Upper Manitou Lake group.

GRANT LAKE GROUP

Intermediate to mafic metavolcanic rocks of the Grant Lake group attain a maximum apparent thickness of over 7 km and extend 17 km northeast to Lower Manitou Lake from the southwestern boundary of the map area. This grour is composed of flows, pillow breccia and pyroclastic-epiclastic deposits in approximately equal amounts. Several distinctive morphological and mineralogical features which characterize this group of rocks are listed in Table 2 and Table 3.

Most flows, whether massive or pillowed, are porphyritic and contain white, equant plagioclase phenocrysts and/or black amphibole-chlorite phenocrysts that range in size from 1 mm to 10 mm; the groundmass is aphanitic to fine-grained, and is quartz- bearing (*see* Table 2). Quartz and carbonate amygdules range in size from 2 mm to 50 mm and commonly comprise up to 30% of an individual flow (Photo 1).

Pillowed flows are slightly less common than massive porphyritic flows. They are characterized by thin pillow selvages and accumulations of interpillow material that are up to 8 cm thick. Pillows range in size from 1 to over 10 m long and 0.5 to 1 m wide; in many places they are highly vesicular to amygdaloidal. Individual flows as thin as 3 m were observed at Grant Lake and at Smoky Bay (local name); however, single flows as thick as 50 m are common. Compound flows with massive bases which pass vertically and laterally into pillowed flows are common in the southwest part of the map area; these flows have a transition zone characterized by incomplete pillow forms and discontinuous quenched-flow contacts. The general impression is that these flows either erupted too quickly or were too viscous to form complete pillow shapes.

Pillow breccia, flow breccia and hyaloclastite deposits are common throughout the Grant Lake group and are most abundant in the Grant Lake area and Napanee Lake area. These deposits are monolithic and contain vesicular and amygdaloidal, rounded to angular, intermediate lava fragments in a fine-grained, hyaloclastite matrix of similar composition. Fragments range in size from 1 cm to 100 cm, make up 10 to 80% of a deposit, and commonly retain chilled margins. The thickness of the deposits ranges in size from 1 m for a single breccia unit in the Smoky Bay (local name) area, to over 100 m thick north of Gates Lake and at the south end of Grant Lake. These thicker deposits are composed of a series of stacked flow units, each with a narrow (3 m to 5 m thick) base that is either massive or pillowed, and a thick (5 m to 40 m) flow or pillow-breccia top.

Intermediate to mafic pyroclastic and epiclastic deposits comprise approximately 30% of the Grant Lake group; these are most abundant between Napanee Lake and Lower Manitou Lake. These deposits are composed of tuff, lapilli tuff and tuff breccia. Their predominant features are described in Table 3. Most deposits are heterolithic, with mafic and intermediate fragments in an intermediate, tuff to lapilli tuff matrix (Photo 2). Lithic intermediate fragments are most common; however, pumiceous fragments always make up a minor component of any pyroclastic deposit in the map area and in some places, most notably at Smoky Bay (local name), they are abundant.

In several places, lithic pyroclasts and rounded to sub-angular lava fragments with chilled margins occur in the same deposit. This indicates that the flow and pillow breccia deposits were reworked and intermingled with pyroclastic deposits. Monolithic pyroclastic rocks are found locally and generally contain plagioclase phenocrystic, rounded to spindle-shaped bombs in a tuffaceous matrix of similar composition. West of Peep Bay, a distinctive tuff breccia containing flow-banded rhyolite clasts in a dark-green tuff matrix was traced discontinuously southwest to Gates Lake and can be used as a marker unit in this area (Photo 3).

An unusual intermediate breccia unit that is over 15 m thick was traced for approximately 1 km along the west side of Smoky Bay (local name) (Photo 4 and Photo 5). This unit contains delicate, angular and sub-rounded fragments, 1 to 50 cm in size; of quenched rock that displays perlitic cracking. These fragments are accompanied by minor flow-banded lithic fragments and 1 cored bomb. The predominance of delicate and angular fragments indicates that the breccia was formed *in situ* and is interpreted by the author to have been formed by a phreato-magmatic eruption, possibly on the flank of a volcanic edifice. These eruptions pierced through and brecciated the older flows that are now represented as fragments in the breccia. Fragments with perlitic cracks

Table 3. Description of intermediate and felsic pyroclastic rocks.

Etta Lake formation

Map units:	2d, e, f, g
Field names:	intermediate tuff, crystal tuff, lapilli tuff, lapillistone, tuff breccia
Location:	interlayerd with Wapageisi Lake group mafic flows along the eastern side of Manitou Stretch and southeast of Lower Manitou Lake
Colour:	fresh surface is grey-green, green; weathered surface is buff, green-grey
Fragment size:	1 mm to 30 cm
Morphology:	generally well bedded, well to poorly sorted; clast and grain gradation is common; clasts are rounded to subangular, heterolithic to monolithic; very thinly bedded to very thickly bedded
Related rocks:	chert; reworked tuff (volcanogenic rocks: metasediments); metabasalts
Remarks:	predominantly intermediate; predominantly feldspathic; distal deposition in deep water

Modal mineralogy: (estimated) n = 6

quartz	0% to 10%	
plagioclase	10% to 40%	$An_{?}$
epidote	10% to 30%	
amphibole	0% to 35%	generally >25% actinolite
chlorite	0% to 15%	average 5%
biotite	trace	green
sericite	0% to 10%	
carbonate	0% to 20%	
other	0% to 5%	opaques, biotite

Grant Lake group

Map units:	2d, e, f, g; 3a, b, c; 1e, f, g
Field names:	intermediate and mafic tuff, lapilli tuff, tuff breccia; intermediate crystal tuff, crystal lapilli tuff; felsic tuff, lapilli tuff, breccia
Location:	west boundary of the map area northeast to Lower Manitou Lake
Colour:	fresh surface is grey, blue-green, green; weathered surface is grey, blue-green, green to dark green
Fragment size:	1 mm to 1 m
Morphology:	poorly to well sorted; angular to sub-rounded clasts; poorly bedded; generally very thickly to extremely thickly bedded; heterolithic to monolithic; clast gradation is common; local scour marks; rare dropstones; rare perilitic cracked fragments, local cored bombs; rare phreato-magmatic breccia; crystal tuff and crystal lapilli tuff is common; pre-lithified clasts are common
Related rocks	intermediate porphyritic flows; extensive pillow breccia and hyaloclastites; common intermingling of hyaloclastite and pyroclasts in the same deposit
Remarks	mixed intermediate and mafic rocks; minor felsic members; quartzo-feldspathic; displays lateral facies change from proximal shallow water deposition to distal deeper water deposition

Modal mineralogy: (estimated) n = 15

quartz	5% to 30%	generally 5% to 10%
plagioclase	20% to 50%	generally 30% to 35% An_{13-37}
epidote	0% to 25%	
amphibole	0% to 35%	generally 0%
chlorite	0% to 20%	
biotite	0% to 10%	
sericite	0% to 25%	
carbonate	0% to 20%	
other	0% to 5%	titanite, opaques

Upper Manitou Lake group

Map units:	2d, e, f, g; 3a, b, c
Field names:	intermediate tuff, crystal tuff, crystal lapilli tuff, lapilli tuff, tuff breccia; felsic tuff, lapilli tuff, tuff breccia
Location:	easterly distribution between Lower Manitou Lake and Syndicate Lake; fault-bounded block north of Syndicate Lake
Colour:	fresh surface is grey to grey-green; weathered surface is white, pale yellow to dark green (depending on metamorphic grade)
Fragment size:	1 mm to 2 m
Morphology:	poorly to well sorted; poorly to well bedded; heterolithic to monolithic; grain gradation is common; scours locally present; cross stratification; angular to rounded clasts are rare; contains ash flow sequence and block and ash deposits
Related rocks:	surrounded by metabasalts; intruded by the Calder Lake sill
Remarks:	predominantly felsic; quartzo-feldspathic; proximal to distal deposition in a deep water environment

Modal mineralogy: (estimated) n = 7

quartz	5% to 30%	generally >15%
plagioclase	20% to 40%	generally 40% An_{8-32}
epidote	0% to 20%	
amphibole	0% to 55%	generally 0%
chlorite	0% to 10%	
biotite	0% to 20%	generally 0%
sericite	0% to 20%	
carbonate	0% to 20%	average 5%
other	0% to 5%	opaques, apatite, fuschite

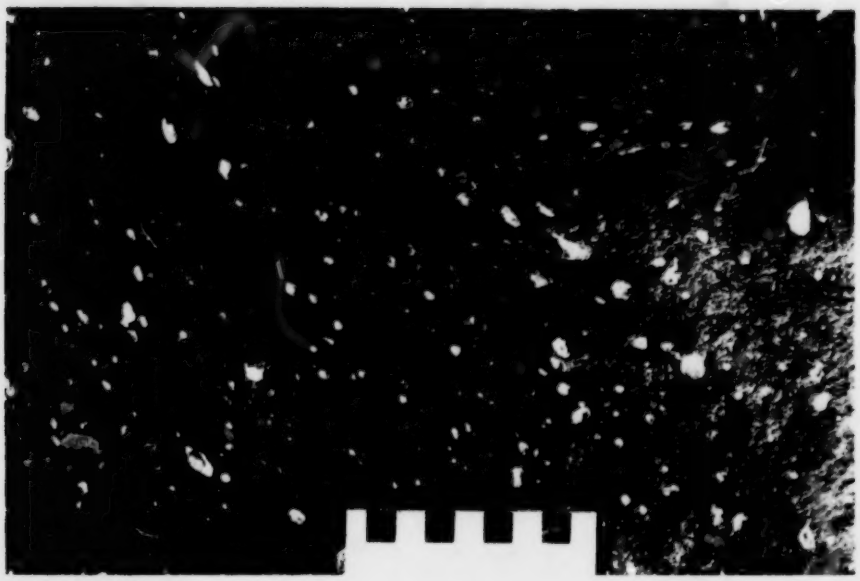

Photo 1. Quartz- and calcite-filled gas cavities and amygdules in andesite flow, Grant Lake group, Grant Lake. The size and density of amygdules indicates a shallow water to subaerial depositional environment.

Photo 2. Heterolithic pyroclastic breccia from the Grant Lake group, Smoky Bay (local name). The head of the hammer is approximately 15 cm long.

were also observed in minor quantities in a lapillistone unit that is approximately 50 cm thick and is located at Gates Lake, where the fragments are rounded and have clearly undergone transport.

Crystal tuff and crystal-lapilli tuff are locally abundant and are characterized by having white, euhedral to anhedral plagioclase crystals in a green to grey lithic tuff matrix. These rocks are common only in the Grant Lake group and help distinguish this group from other groups of intermediate rocks in the map area.

For the most part, pyroclastic and epiclastic deposits are poorly sorted, thickly bedded units 5 to 30 m thick, that are matrix to clast supported. Thinly-bedded lapilli tuff to laminated tuff occur locally and display clast and

Photo 3. Rhyolite clast tuff-breccia from the Grant Lake group, small lake west of Peep Bay. This unit is a good marker horizon in the Peep Bay to Gates Lake area. Note the flow banding in the clast located to the right of the hammer head. The clasts were derived from the Straw Lake area, located west of the map area. The hammer is approximately 40 cm long.

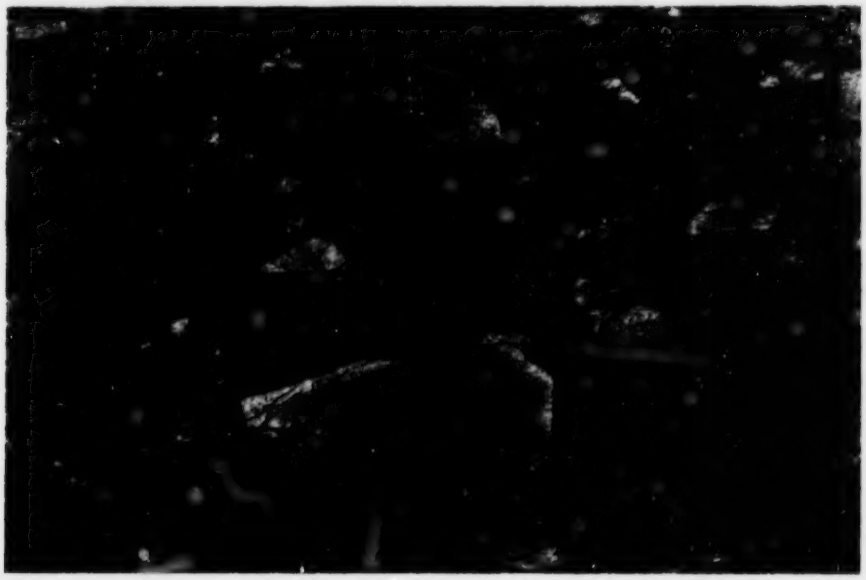

Photo 4. Phreato-magmatic breccia form the Grant Lake group, Smoky Bay (local name). Note the perlitic cracking and angular corners on the largest fragment. These features denote quenching and minimal transportation of the fragments. This unit was possibly formed by an eruption on the flank of a volcano. The pencil is 14 cm long.

grain gradation, scouring marks and rarely, dropstone features. Laminated tuff units, up to 8 cm thick, commonly cap thick tuff breccia units at Flossie Lake and Smoky Bay (local name) and provide reliable stratigraphic top indicators in this part of the map area.

Rocks described as intermediate feldspar porphyry occur in: 1) the Grant Lake group within the amphibolite facies contact metamorphic aureole adjacent to the Lawrence Lake Batholith; and 2) the Lawrence Lake Batholith, as xenoliths. This rock type is characterized

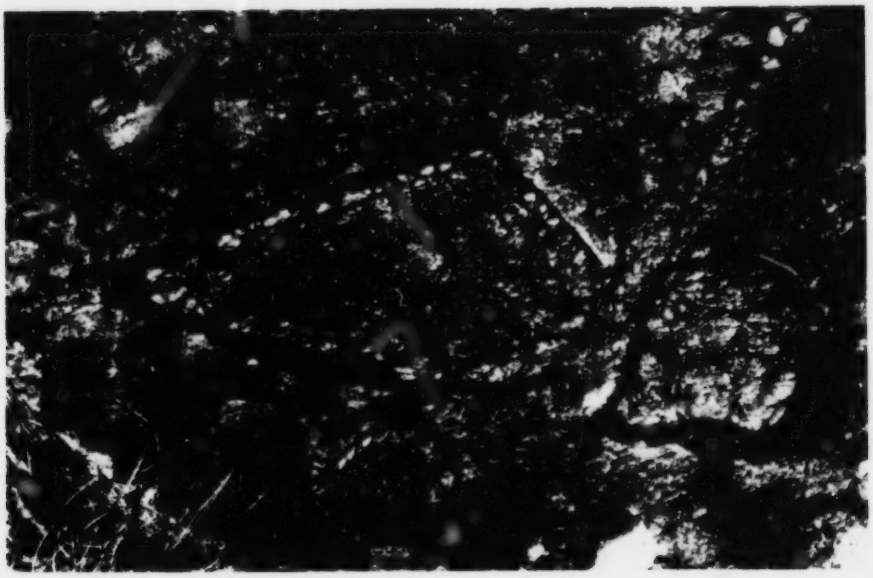

Photo 5. Phreato-magmatic breccia, Grant Lake group, northeast end of Smoky Bay (local name). The large fragment was quenched *in situ* and displays evidence of a minimal amount of transportation. The right end has spalled off of the fragment.

by white, euhedral to anhedral feldspar crystals, 1 to 7 mm in size, in a dark green to black biotitic groundmass. In thin section, the feldspar phenocrysts are extensively altered to sericite and epidote and the groundmass is highly recrystallized. Intermediate amphibolite, which is foliated and plagioclase-free, is commonly associated with the feldspar porphyry.

There are clearly defined lateral changes in the lithology and morphology of the rocks within the Grant Lake group. From the southwest corner of the map area to Gates Lake, massive flows and pillowed flows are more abundant than flow breccia and pillow breccia, which in turn are more abundant than pyroclastic-epiclastic deposits. From Gates Lake to the central part of Grant Lake, flow breccia and pillow breccia are more abundant than flows and pyroclastic-epiclastic deposits. From the central part of Grant Lake to Lower Manitou Lake, pyroclastic-epiclastic deposits are more abundant than pillow breccia and flows combined.

Accompanying the changes in the morphology is a change in the size and abundance of amygdules. Amygdules in the southwest part of the Grant Lake group are large, up to 5 cm, and constitute up to 30% of flows. In the northeast part of the group, amygdules are generally small, 1 to 5 mm, and constitute less than 10% of flows. This trend is not uniform, as non-amygdaloidal flows or flows with small amygdules occur locally in the southwest part of the group.

Based on facies models presented by Easton and Johns (1986), the morphology change in the Grant Lake group is interpreted by the author to represent a lateral change in depositional environment from a very shallow water to subaerial, proximal environment in the southwest, to a deeper water, distal environment in the northeast.

WAPAGEISI LAKE GROUP–ETTA LAKE FORMATION

Intermediate epiclastic rocks and minor pyroclastic rocks form several continuous units, up to 3 km long and 500 m thick, within the mafic metavolcanic flows of the Wapageisi Lake group. These units are interbedded with chert, volcanogenic wacke and siltstone, and extend northeast of the map area. They are correlated with the Etta Lake formation (Blackburn 1976, 1982).

Intermediate metavolcanic rocks of the Etta Lake formation are composed predominantly of tuff, lapilli tuff and tuff breccia with minor quantities of crystal tuff and lapillistone (Table 3). These rocks are feldspathic and generally contain black to green actinolite, and hornblende porphyroblasts that formed within the contact metamorphic aureole of the Irene–Eltrut Lakes complex. Clasts are generally well rounded to subangular, plagioclase porphyritic and range in size from 1 mm to 20 cm. Amygdules and vesicles are absent and pumiceous fragments are only present locally in the northern most part of the formation.

The epiclastic deposits are mostly heterolithic, well sorted, well bedded and clast supported. Clast and grain gradation are common. Cherty interbeds display slump features, flame structures, scours and rarely, cross laminations and ball-and-pillow structures. Locally, pyrite and graphite accompany these rocks. Diamond-drill hole logs indicate that chalcopyrite and sphalerite occur sporadically (*see* "Economic Geology"). For the most part, the Etta Lake formation contains re-sedimented

metavolcanic rocks formed in a deep water, distal environment having minor, chemically exhaled chert and very minor clastic metasedimentary rocks.

Intermediate metavolcanic rocks mapped by Smith and Stephenson (1988) at Vista Lake are similar to metavolcanic rocks in the Etta Lake formation. Pyroclastic and epiclastic deposits are the most abundant morphology and are accompanied by intermediate flows and interflow metasedimentary rocks. These deposits may represent a more proximal depositional equivalent of the Etta Lake formation (P.M. Smith, Ontario Geological Survey, personal communication, 1989).

UPPER MANITOU LAKE GROUP

Intermediate pyroclastic-epiclastic rocks form part of a litho-stratigraphic group extending for 6 km in an east-northeastly direction from Syndicate Lake to Lower Manitou Lake. A fault-bounded block of intermediate and felsic metavolcanic rocks extends northward from Syndicate Lake for at least 2 km and is part of the same group. These rocks are correlated with the Upper Manitou Lake group (Blackburn 1976, 1982; C.E. Blackburn, Ministry of Northern Development and Mines, personal communication, 1988) and their field characteristics are described in Table 3.

Intermediate rocks of the Upper Manitou Lake group are composed of tuff, lapilli tuff and tuff breccia, with minor amounts of crystal tuff and crystal-lapilli tuff. These rocks are quartzo-feldspathic, and have a higher percentage of free quartz than rocks of either the Grant Lake group or the Etta Lake formation. Clasts range in size from 1 mm to over 2 m and range in composition from basalt to rhyolite; many of the latter are epidotized pumice fragments. Fragments are rounded to angular and amygdules are generally absent.

Members of the Upper Manitou Lake group have a diverse morphology, with heterolithic, poorly sorted to chaotic deposits being the most common. Large (2 m) felsic blocks supported in an intermediate tuff matrix occur along the north shore of Calder Lake and are interpreted as debris flows derived by mass slumping off the flanks of a volcanic edifice. North of Syndicate Lake, deposits with felsic fragments in a hornblende-bearing matrix are also interpreted to have formed by debris flows.

South of Calder Lake and along the southern shore of the western-most bay of Lower Manitou Lake, epiclastic deposits occur; beds of intermediate tuff breccia 1 to 10 m thick are separated by tuff and lapilli tuff beds that are 0.5 to 3 m thick. These deposits have well developed bedding planes, grain gradation and laminations.

Along the north shore of Lower Manitou Lake, intermediate crystal lithic tuff, crystal-lapilli tuff and their reworked equivalents form a distinctive sequence of rocks. Feldspar crystal-lapilli tuff grades vertically into crystal tuff that contains epidotized pumice fragments up to 30 cm in size. The crystal tuff gradually becomes more lithic in character as the feldspar crystals become more abraded and broken. Graded tuff beds and beds of centimetre-sized pebbles overlie the crystal tuff. Trough cross stratification and large scours filled with rounded intermediate metavolcanic cobbles occur locally. The top of the sequence is capped by laminated tuff and a 15 cm thick mudstone bed. Overlying the mudstone is another crystal-lapilli tuff unit.

Photo 6. Heterolithic block and ash pyroclastic deposit from the Upper Manitou Lake group, west bay of Lower Manitou Lake. Note the rind on the clast in centre of photo (*see* arrow).

North-striking brittle faults disrupt and offset this sequence such that a complete section is not exposed; however, the author estimates the total thickness of the sequence to be approximately 100 m. This sequence is interpreted by the author to represent a subaqueous pyroclastic flow having a reworked upper portion (Easton and Johns 1986; Fiske and Matsuda 1964).

On a reef in Lower Manitou Lake, a heterolithic breccia with subangular clasts, 5 cm to 1 m in size, is exposed (Photo 6). There is very little matrix and several of the clasts have a fine-grained rind surrounding them. This rock is characteristic of a block and ash deposit (G. Johns, Ontario Geological Survey, personal communication, 1988).

The lack of vesicles and amygdules, combined with abundant evidence for water reworking, indicates that

the Upper Manitou Lake group was deposited in relatively deep water. The presence of block and ash deposits and pyroclastic flow deposits indicates a depositional environment proximal to a submarine vent.

Felsic Metavolcanics

Felsic metavolcanic rocks are volumetrically minor in the Manitou Stretch area and comprise only a portion of the Upper Manitou Lake group and a few units within the Grant Lake group.

GRANT LAKE GROUP

On Mister Lake, felsic pyroclastic breccia and lapilli tuff occur as narrow units 10 to 20 m thick, interlayered with intermediate and mafic metavolcanic rocks of the Grant Lake group. These deposits weather white, are quartz-phyric and contain rhyolite clasts in a quartzo-feldspathic tuff matrix. They have a limited strike extent within the map area but are more voluminous along strike to the west of the map area (Edwards 1983).

Felsic tuff and sericite schist occur within the Grant Lake group as isolated units located 1.5 km southwest of Davis Lake. Here, the rocks are pervasively iron-carbonate altered and contain trace amounts of disseminated pyrite. Shearing has obscured many of the primary features; however, in places the rock is quartz-phyric and may be a quartz porphyry.

A quartz porphyry, unique in the map area, is exposed on the portage between Grant and Napanee lakes. This rock weathers white, is highly fractured and contains millimetre-sized quartz phenocrysts in a fine-grained to aphanitic quartz-bearing groundmass. The fresh surface is dark grey to brown due to minor, but pervasive, iron carbonate alteration. The quartz porphyry has an irregular shape and several dike-like extensions intrude the surrounding Grant Lake intermediate metavolcanic rocks. At one outcrop, lapilli-sized fragments are present; this suggests that the porphyry had an extrusive phase.

Several quartz-feldspar porphyry dikes and felsite dikes intrude the Grant Lake group at various locations. These dikes are generally less than 5 m wide, are structurally controlled, have a northeast or north strike and generally transect stratigraphy. They are late-stage intrusions and their relation to volcanism is uncertain.

UPPER MANITOU LAKE GROUP

Felsic metavolcanic rocks constitute approximately 50% of the Upper Manitou Lake group and underlie Syndicate Lake and the west end of Calder Lake. Pyroclastic-epiclastic deposits composed of tuff, lapilli tuff, breccia and tuff breccia are the most common deposits and are described in Table 3.

Felsic tuff and lapilli tuff weather white and are most abundant on Calder Lake where they are well bedded, well sorted, monolithic units, 30 cm to 3 m thick. They are interbedded with dark green to black, intermediate lapilli tuff units of approximately equal thickness to that of the felsic tuff and lapilli tuff and many outcrops display several dark and light bands. Grain and clast gradation is common and in one location, features resembling ball-and-pillow soft sediment loading structures are present. These deposits are interpreted to represent a rapid deposition of material in a distal to proximal environment (Easton and Johns 1986).

Heterolithic to monolithic breccia, tuff breccia and lapilli tuff are most common at Syndicate Lake and at the northwest shore of Calder Lake. Clasts are rounded to subangular, 1 cm to over 1 m in size and are composed predominantly of rhyolite and dacite with rare occurrences of mafic scoria. Green mica, usually found in the form of mineral streaks, occurs within siliceous clasts in some of the deposits. This is interpreted to indicate that hydrothermal fluids affected the pyroclastic rocks.

In many places there is very little matrix in the breccia; where present, it occurs as thin layers draped around the clasts. In other places, felsic clasts are supported in a black, intermediate tuff matrix which contains garnet and biotite. These coarser pyroclastic deposits are poorly sorted, poorly stratified and display no clast gradation. They are interpreted as pyroclastics deposited in a proximal environment (Easton and Johns 1986).

Clastic and Chemical Metasedimentary Rocks

Clastic and chemical metasedimentary rocks constitute a very minor portion of the supracrustal rocks in the Manitou Stretch area and form mappable units only within the Etta Lake formation of the Wapageisi Lake group. Minor metasedimentary units occur within the Grant Lake group, and magnetite-bearing ironstone clasts occur in a mafic epiclastic deposit within the Pipestone–Cameron–Manitou deformation zone on the west shore of Lower Manitou Lake. *In situ* magnetite ironstone does not occur in the map area and the most likely provenance for the ironstone clasts is on Beaverhead Island, approximately 13 km to the northeast (*see* Blackburn 1976, p.33-35).

WAPAGEISI LAKE GROUP–ETTA LAKE FORMATION

Chert, cherty siltstone, volcanogenic siltstone, and sandstone and derived schist are interbedded with intermediate pyroclastic-epiclastic deposits of the Etta Lake formation. Chert and cherty siltstone occur as white weathering, fine-grained to aphanitic beds that are 5 to 80 mm thick and form units up to 25 m thick. Parallel laminations, flame structures and low-angle scour marks, indicative of quiet water deposition, are all common bed forms.Grain gradation in the more silty beds is rarely present. Pyrite and graphite are sporadically associated with these rocks, and where the rocks are sheared, geochemically anomalous gold values may occur (*see* "Economic Geology").

Within the Etta Lake formation, grey to brown weathered beds of siltstone and sandstone are 5 to 30 cm thick and generally occur at the stratigraphic top of coarser epiclastic-pyroclastic units. The siltstone and sandstone are also the dominant rock types in metasedimentary units which attain thicknesses of up to 50 m. Grain gradation, scour marks, load casts and ball-and-pillow structures are common primary features. Clastic feldspar grains are poorly abraded and, for the most part, retain their crystal shapes. In a number of places, sandstone and siltstone units were observed to grade vertically and laterally into metavolcanic tuff over an area tens of metres wide. Clearly, the provenance of these metasedimentary rocks was metavolcanic rocks of the Etta Lake formation and consequently, the term "volcanogenic" is appropriate.

GRANT LAKE GROUP

White chert and green to grey reworked tuff occur as thin, laterally discontinuous beds within the Grant Lake group and never form distinct mappable units. These 2 rock types are best exposed on a small island at the northeast end of Napanee Lake where chert laminae, up to 5 mm thick, are interbedded with massive reworked tuff beds that are up to 30 cm thick. These rocks are commonly interlayered with intermediate pyroclastic-epiclastic deposits and are distributed between Napanee Lake and George Lake. This portion of the Grant Lake group was previously interpreted to have been deposited in a distal environment (see above) and the presence of these metasedimentary rocks supports this interpretation.

Mafic to Ultramafic Intrusions

Mafic to ultramafic intrusions are of two main types in the Manitou Stretch area. Ultramafic-mafic dikes and sills with clearly defined intrusive contacts occur at Napanee Lake, Davis Lake and Harris Lake. They display field evidence of compositional layering and are post-volcanic in origin.

The second type of mafic intrusion occurs at Peep Bay and in the Calder Lake area. These intrusions display complex field relationships with their host metavolcanic rocks and are interpreted to be synvolcanic to post-volcanic in origin. They commonly resemble phaneritic mafic flows.

The Peep Bay intrusion is composed of gabbro, granophyric gabbro and derived schist. At the southwest end of Peep Bay, the intrusion is a coarse-grained gabbro containing granophyric and pegmatitic pods. Anorthositic gabbro, composed of euhedral plagioclase in a mafic groundmass, is a distinctive rock type and occurs in 2 trenches sunk by Birch Bay Gold Mines, Limited (*see* "Economic Geology"). In one place, metavolcanic xenoliths were observed. Locally, the granophyric gabbro phase of the intrusion is magnetite bearing. In thin section, interstitial quartz, skeletal ilmenite and graphic intergrowth of quartz and plagioclase are common. Along strike to the northeast, the rock becomes fine grained and locally contains calcite amygdules. This suggests that the intrusion is actually a large ponded flow or possibly a shallow sill which provided magma to flows on the paleosurface.

In an old trench at Gates Lake, anorthositic gabbro similar to that at Peep Bay was observed. A positive aeromagnetic signature (Geological Survey of Canada 1988a) extends from Gates Lake to Peep Bay and is coincident with the gabbro intrusion. These data lead the author to believe that at Gates Lake the gabbro intrusion is the same, or similar to, that at Peep Bay.

The gabbro intrusion at Peep Bay and Gates Lake occurs within the Pipestone–Cameron–Manitou deformation zone and consequently is highly fractured and locally sheared. Gold mineralization accompanied by silica, and iron-carbonate alteration is preferentially sited in the fractures and shear zones of the intrusion (*see* "Economic Geology").

In the Calder Lake area, a mafic intrusion up to 200 m thick extends over 5 km from Lower Manitou Lake to Syndicate Lake. Although this intrusion clearly cuts members of the Upper Manitou Lake group and the Blanchard Lake group, it is broadly conformable with the east-northeast-striking stratigraphy and is referred to by the author as the "Calder Lake sill".

The Calder Lake sill is a multi-phase intrusion composed of gabbro, quartz gabbro and plagioclase-phyric gabbro. Gabbro is the most abundant phase and is a massive, dark green, medium- to coarse-grained rock. Macroscopically, it closely resembles phaneritic flows of the Blanchard Lake group. Microscopically, the gabbro contains more titanite and leucoxene than the flows.

Quartz gabbro is a coarse-grained rock containing 5 to 10 mm sized, white to blue quartz phenocrysts in a pinkish-white to green groundmass. On the south shore of Calder Lake, the quartz gabbro appears to grade into gabbro. As observed in thin section, graphic intergrowth of quartz and plagioclase is characteristic of this rock. Calcite and titanite are common accessory minerals.

Plagioclase-phyric gabbro is densely phenocrystic with an average of 60% white, anhedral plagioclase phenocrysts, that range in size from 1 to 6 cm, set in a dark green, fine-grained groundmass. This unit is best exposed along the southwest shore of Calder Lake and on the south shore of Syndicate Lake, where it attains a maximum thickness of 120 m. This rock is associated only with the sill and contains a higher phenocryst content than plagioclase-phyric basaltic flows.

Compositional layering of the intrusion is not clearly defined; however, quartz gabbro and plagioclase-phyric gabbro tend to occur most commonly along the northern contact of the sill. A contact metamorphic aureole is developed within 50 m of the sill. This is demonstrated by the presence of garnet and biotite in the matrix of intermediate and felsic pyroclastic rocks on Calder and Syndicate lakes. The sill is foliated and metamorphosed and has hornblende-, epidote- and chlorite-bearing mineral assemblages which are compatible with greenschist grade metamorphism (Winkler

1979). North-striking faults sinistrally offset the sill and both ends are terminated by members of this fault set.

Ultramafic to mafic intrusions in the Napanee–Davis–Harris lakes area are compositionally and morphologically distinct. These intrusions occur as dikes and sills with clearly defined contacts and have distinct aeromagnetic and vertical gradient of the magnetic field signatures (Geological Survey of Canada 1988a, 1988b). The intrusions are composed of pyroxenite-, peridotite- and plagioclase-bearing ultramafic rocks, gabbro, quartz gabbro and granophyric gabbro.

The intrusion at Napanee Lake is an east-northeast-striking sill-like body up to 3 km long and 180 m wide that has intruded intermediate metavolcanic rocks of the Grant Lake group. Dark green to black, medium-grained pyroxenite occurs along the northwest side of Napanee Lake. This rock is massive to sheared and contains over 95% tremolite, magnesium-rich chlorite, talc and primary basaltic hornblende with only a minor amount of plagioclase. Pyroxenite appears to grade into quartz gabbro-tonalite, although field relations are obscured by vegetation and Napanee Lake.

Quartz gabbro weathers grey to white and is an equigranular rock that contains up to 30% blue quartz phenocrysts, 1 to 5 mm in size, in a magnesium-rich chlorite-, calcite- and plagioclase-bearing groundmass.

Granophyric gabbro is exposed along the south shore of Napanee Lake. This rock weathers dark green, is medium grained, and is generally equigranular; although pegmatitic feldspar and hornblende patches are erratically distributed throughout the rock. Epidote and hematite are locally developed along the eastern contact of the intrusion and in the host metavolcanic rocks. These rocks commonly weather bright green to pink. The granophyric gabbro is interpreted to be part of the same intrusion as the pyroxenite and quartz gabbro; however, this is not certain as Napanee Lake covers most of the intrusion. It is possible that there are several small intrusions in this area.

At the east end of Davis Lake, altered pyroxenite-peridotite is exposed in a northeast-striking intrusion. These rocks are equigranular, black weathering and medium grained. In thin section, they contain tremolite, talc and epidote with minor amounts of serpentine, primary basaltic hornblende and calcite. The intrusion is geographically separated from those at Napanee Lake and the west end of Davis Lake, and is therefore interpreted to be a separate sill.

A northwest-striking ultramafic-mafic intrusion extends approximately 3 km from Davis Lake to Harris Lake and has an average thickness of 120 m. The intrusion can be traced on an airborne magnetic map (Geological Survey of Canada 1988a) and is discordant with the northeast-striking stratigraphy of the Grant Lake group and the regional foliation. The intrusion is characterized by compositional layering that is best exposed on 2 islands in the central part of Harris Lake. Most of the following discussion is based on observations made at these locations.

At the eastern contact, the host metavolcanic rocks and the first 8 to 10 cm of the intrusion are sheared. Dark green to black, coarse-grained pyroxenite-peridotite containing metavolcanic and mafic hornblende-bearing xenoliths occur over the next 30 cm of the intrusion. The pyroxenite-peridotite is at least 10 m thick and is composed of talc, tremolite, chlorite, primary brown amphibole and serpentine, plus magnetite that was derived from olivine. The central part of the intrusion is characterized by plagioclase-bearing rocks that have white, euhedral to anhedral plagioclase crystals that erratically increase from 5% to 25% of the rock, from east to west. Gabbro, pyroxenitic gabbro and, locally, quartz gabbro, similar to that described at Napanee Lake, are developed along the western contact of the intrusion. The observed systematic change in rock type across the intrusion is interpreted by the author to result from crystal fractionation.

The ultramafic-mafic suite of rocks intrudes all members of the Grant Lake group including a large silicified zone centred on Harris Lake. This indicates that the suite is postvolcanic in origin. The intrusion at Napanee Lake is sheared and the large intrusion extending between Davis and Harris lakes is locally foliated. For these reasons, the rock suite is interpreted to be syn- to late-tectonic in origin. The Lawrence Lake Batholith is intruded by ultramafic to felsic dikes which are characterized by biotite, amphibole, relic olivine, abundant opaque minerals, and high strontium and high modal titanite levels (Davis and Edwards 1985). The geochemistry of 2 members of the ultramafic-mafic suite of intrusions in the map area is presented in Table 7.

The ultramafic rocks in the map area contain low levels of strontium, no modal titanite and are mineralogically devoid of biotite. Therefore, they do not appear to be related to the suite described by Davis and Edwards (1985). Ultramafic-mafic intrusions in the map area are mineralogically and geochemically similar to those described by Blackburn (1979) within the Atikwa–Lawrence Lake Batholith in the Upper Manitou Lake area. Based on the limited field and geochemical evidence, the petrogenetic significance of the ultramafic-mafic suite in the Manitou Stretch area remains uncertain.

Felsic Intrusions

Felsic granitoid intrusions are located in the eastern and northwestern parts of the Manitou Stretch area. The eastern intrusion, named the Irene–Eltrut Lakes complex (Blackburn 1982, Blackburn et al. 1985), is subdivided by the author into a main granodiorite pluton and the compositionally zoned Bretz Lake stock. The western felsic intrusion is referred as the Lawrence Lake Batholith which is part of the larger Atikwa–Lawrence Lake Batholith (Davis and Edwards 1985, Edwards and Davis 1984).

IRENE–ELTRUT LAKES COMPLEX

The main granodiorite pluton of the Irene–Eltrut Lakes complex extends from Aronson Lake south to Kahabeness Lake and southeast to Vickers Lake (Smith and Stephenson 1988). This pluton is very homogeneous and is composed of medium-grained, equigranular, massive granodiorite to quartz monzonite with minor amounts of tonalite around the borders of the pluton (Table 4). Tonalite dikes and small plugs also intrude the adjacent supracrustal rocks and are accompanied by minor aplite and pegmatite dikes and pods. There is little variation in the mineralogy of the pluton, biotite is generally more abundant than hornblende and oscillatory zoning of plagioclase is common. The pluton has been metamorphosed as indicated by the formation of epidote and sericite in the cores of plagioclase crystals.

A foliation, interpreted to be synplutonic, is weakly developed parallel to the contact of the pluton. Several north- to northeast-striking brittle to brittle-ductile faults cut the periphery of the pluton but do not appear to extend into the interior of the intrusion. These faults extend into the supracrustal rocks; the largest fault extends southeast from Eyelid Lake to the Vista Lake area (Smith and Stephenson 1988), and defines, in part, the supracrustal-granitoid contact. Based on descriptions by Blackburn (1981, 1982), the main granodiorite pluton is comparable to the early granodiorite phase of the Meggisi Lake lobe of the Irene–Eltrut Lakes complex.

BRETZ LAKE STOCK

The Bretz Lake stock is a circular intrusion, centred around Bretz Lake, which covers approximately 20 km² in both the Manitou Stretch and the Vista Lake areas (Smith and Stephenson 1988). The northern, eastern and southern sides are composed of monzonite to quartz monzonite, and the western and central parts of the pluton are composed of granite (Table 4).

The western and southern margins of the stock are sheared and the foliation decreases in intensity towards the interior of the stock; this indicates that the intrusion is syn- to late-tectonic in origin.

There appears to be a narrow metavolcanic septum separating the main granodiorite pluton of the Irene–Eltrut Lakes complex from the Bretz Lake stock in the Vista Lake area (Smith and Stephenson 1988). Aeromagnetic patterns (Geological Survey of Canada 1988a) suggest that the metavolcanic septum extends to James Lake, although mapping did not confirm this.

Staining has determined that the Bretz Lake stock is characterized by potassium feldspar phenocrysts that commonly contain sodic cores. Biotite is the only mafic mineral present and constitutes up to 25% of the monzonite phase. In thin section, biotite and iron-rich chlorite are commonly intergrown with magnetite and hematite. Abundant accessory apatite and titanite (up to 2%) is another characteristic feature of the stock (Table 4).

Both the granodiorite pluton of the Irene–Eltrut lakes complex and the Bretz Lake stock are in abrupt contact with the supracrustal rocks. There is very little stoping as indicated by the paucity of xenoliths, and in many places the metavolcanic-granitoid contact can be defined within 1 m. There is a narrow (800 m) contact metamorphic aureole developed in the supracrustal rocks around the pluton. The scarcity of migmatite indicates that the temperature of intrusion was not high.

LAWRENCE LAKE BATHOLITH

The northwestern part of the map area is occupied by a portion of the Lawrence Lake Batholith. Four intrusive phases were recognized and are described in Table 4.

Quartz diorite with minor amounts of diorite and gabbro occur as xenoliths and pods within migmatite around the periphery of the Lawrence Lake Batholith. These rocks are also found in a small pluton on a peninsula in western Harris Lake. This foliated to massive pluton is dark green, coarse grained and equigranular with prominent amphibole porphyroblasts. Biotite, amphibole, epidote and blue quartz are the most common minerals. Specularite, mafic to ultramafic xenoliths and finer grained, chilled quartz diorite occur along the southern side of the pluton. The northern side of the pluton is intruded by tonalite and locally contains metavolcanic xenoliths. The quartz diorite is comparable to the Bluffpoint Quartz Diorite described by Edwards (1983) and ascribed by Davis and Edwards (1985) to be one of the oldest phases (2733 ± 1 Ma, zircon U-Pb) in the Lawrence Lake Batholith. According to Davis and Edwards (1985), the quartz diorite formed by the mixing of differentiation products of layered intrusions with the partial melts of basaltic rocks.

Within the map area, foliated tonalite is the most abundant rock type of the Lawrence Lake Batholith. Based on field relations, it is younger than the border-phase quartz diorite. The tonalite contains numerous quartz diorite and metavolcanic xenoliths and comprises the major component of migmatite developed at the contact with the supracrustal rocks. Hornblende, biotite, plagioclase (An_{32-38}) and quartz are the major essential minerals; they are accompanied by accessory epidote. Titanite, apatite and opaque minerals are almost totally absent. The tonalite is foliated, locally gneissic and rarely sheared. This phase is correlated with tonalite-trondhjemite of the Lawrence Lake Batholith described as Group 3 by Davis and Edwards (1985). Group 3 rocks are 10 to 14 million years younger than the quartz diorite and are believed to have been formed by partial melting of metabasalt, leaving an amphibole- or garnet-rich residue (Davis and Edwards, 1985).

Pink weathering, foliated quartz monzonite to granodiorite occurs along the northwestern shore of Harris Lake; it contains xenoliths of both tonalite and the quartz diorite border phase. Massive quartz monzonite to granodiorite dikes also occur within the interior of the Lawrence Lake Batholith. At one place in the northwestern corner of the map area, massive, undeformed, potassium feldspar porphyry granite intrudes foliated

Table 4. Description of felsic plutonic rocks.

Irene–Eltrut Lakes Complex

Map units:	6a, b, c, d
Field names:	tonalite, granodiorite, aplite and pegmatite dikes
Location:	eastern boundary of map area
Colour:	fresh surface is pink to grey; weathered surface is white, grey, pink
Grain size:	3 to 7 mm
Remarks:	generally equigranular; massive; foliated only near the contact with supracrustal rocks; few (if any) xenoliths; lamprophyre dikes are locally present in the Aronson Lake area; the batholith is deformed by late-stage north-striking brittle to brittle-ductile faults; homogeneous tonalite to granodiorite

Modal mineralogy: (estimated) n = 5

quartz	10% to 25%	
plagioclase	40% to 48%	An_{32-39}
microcline	5% to 10%	
biotite	5% to 15%	
hornblende	0% to 10%	
epidote	0% to 10%	
sericite	0% to 10%	
chlorite	0%	
other	trace to 5%	most commonly titanite and opaques

plagioclase commonly displays oscillatory zonation; biotite is fresh, green, mineralogy is not highly altered, metamorphosed or deformed; locally quartz phenocrystic

Bretz Lake stock

Map units:	6e, f, g
Field names:	monzonite, quartz monzonite, granodiorite, granite
Location:	centred on Bretz Lake; extending from Manitou Stretch to James Lake
Colour:	fresh surface is red, red-brown; weathered surface is pink, red
Grain size:	5 to 10 mm groundmass; up to 5 cm for potassium feldspar phenocrysts
Remarks:	generally potassium feldspar porphyritic; contacts are sheared; mineralogy is altered (oxidized); pluton shows distinct phase zonation with monzonite to quartz monzonite along the north, east and south peripheries, and with granite in the central part and west boundary of the pluton; has a distinct airborne magnetic signature

Modal mineralogy: (estimated) n = 4

quartz	5% to 20%	
plagioclase	40% to 50%	
microcline	10% to 25%	
biotite	0% to 15%	always chloritized
hornblende	0% to trace	
epidote	0% to 3%	
sericite	5% to 10%	
chlorite	1% to 5%	
carbonate	5%	
other	trace to 5%	apatite, magnetite

pluton is oxidized; high percentage of apatite magnetite; myrmekitic texture; potassium feldspar phenocrysts with sodic cores common; antiperthite common; plagioclase highly sericitized and carbonitized

Lawrence Lake Batholith

Map units:	7a, b, c, d, e, f
Field names:	quartz monzonite, granodiorite, tonalite, diorite, quartz diorite, granite, aplite and pegmatite dikes, migmatite
Location:	northwest boundary of map area
Colour:	fresh surface is grey, white, pink, green; weathered surface is pink, grey, dark green
Grain size:	1 to 5 mm groundmass; up to 1 cm for potassium feldspar phenocrysts in granite
Remarks:	tonalite, quartz diorite, migmatite and granodiorite are generally foliated, gneissic or sheared; late-phase granite and quartz monzonite is massive; migmatite, xenoliths and gneiss common along the contact with the supracrustal rocks; the batholith is very heterogeneous; border-phase quartz diorite and migmatite intruded by tonalite intruded by quartz monzonite, granodiorite and granite

Modal mineralogy: (estimated) n = 5

quartz	10% to 40%	
plagioclase	30% to 60%	An_{28-33}
microcline	0% to 20%	generally < 5%
biotite	10%	green
hornblende	0% to 20%	
epidote	5% to 20%	generally 5%
sericite	1% to 5%	
chlorite	0% to 10%	only in the most mafic members
other	0% to 1%	opaques

highly variable mineralogy except for biotite; almost total absence of accessory minerals such as titanite, apatite; minerals become less altered farther from contact with supracrustals

tonalite. The quartz monzonite to granodiorite rocks are clearly the youngest intrusive phases identified in the field and may be contemporaneous. These rocks appear to be related to Group 5 late tectonic plutons described by Davis and Edwards (1985), although there were no geochemical analyses performed to corroborate this interpretation. These rocks were interpreted by Davis and Edwards (1985) to have formed by partial melting of the foliated tonalite (Group 3 rocks).

The border quartz diorite phase and tonalite phase of the Lawrence Lake Batholith are foliated, locally gneissic and rarely sheared. Structural trends in the batholith are similar to structural trends in the adjacent supracrustal rocks and these are similar to the deformation pattern within the Pipestone–Cameron–Manitou deformation zone, approximately 8 km to the southeast. This indicates that the intrusion and crystallization of the batholith was complete prior to deformation and the batholith is pre-tectonic in origin.

The contact between the supracrustal rocks and the Lawrence Lake Batholith is gradational and is characterized by extensive development of migmatite and recrystallized metavolcanic rocks mapped as intermediate feldspar porphyry . Local gneissic banding, parallel to the contact, is characterized by alternating quartzofeldspathic and mafic mineral layers. A contact metamorphic aureole up to 2 km wide is developed in the supracrustal rocks around the Lawrence Lake Batholith, which implies that the temperature of intrusion was high.

Mafic Intrusions (Lamprophyre)

Lamprophyre dikes occur at Aronson Lake and at Harris Lake in the Manitou Stretch area. At Harris Lake, a narrow lamprophyre dike, 15 cm wide and 3 m long, intrudes foliated tonalite of the Lawrence Lake Batholith. This grey dike has chilled contacts and biotite and amphibole phenocrysts in the interior.

Lamprophyre dikes occur at Aronson Lake within the main granodiorite of the Irene–Eltrut Lakes complex, near the northern contact with the supracrustal rocks. These are coarse-grained equigranular dikes with black to brown weathered surfaces and mottled black and white fresh surfaces. Biotite and plagioclase are the major essential minerals with carbonate and opaque minerals occurring in significant, but lesser, quantities. The dikes are up to 5 m wide and some were traced for 50 m along the lakeshore.

CENOZOIC

Quaternary And Recent

The Manitou Stretch area is a rocky terrain with thin, discontinuous glacial deposits. Low-lying areas are filled with recent organic deposits and are generally swampy. Cowan (1987) reported that similar features were prevalent east and northeast of the map area.

Glacial striations, chatter marks and, rarely, glacial fluting, were observed on lake shoreline outcrops. These features all indicate glacial advance trending $200° \pm 10°$.

GEOCHEMISTRY

Nineteen rocks were selected for whole rock major oxide analysis and selected trace element geochemical analysis; all analyses were performed by the Geoscience Laboratories, Ontario Geological Survey. As the interpretation of geochemical data for the Wapageisi Lake group, Blanchard Lake group and Upper Manitou Lake group is adequately summarized elsewhere (Blackburn 1982), sampling concentrated on the Grant Lake group. Both the Wapageisi Lake group and the Blanchard Lake group are composed of mafic tholeiitic rocks (Blackburn 1982) and the Upper Manitou Lake group is composed predominantly of intermediate and felsic calc-alkalic rocks (Blackburn 1979, 1982). The geochemistry of the few samples of these groups submitted by the author from the Manitou Stretch area agrees with the results obtained by Blackburn (1979, 1982) (*see* Table 7).

Edwards and Davis (1984) present geochemical data from felsic and intermediate metavolcanic rocks contiguous with the Grant Lake group in the Straw Lake area. The presentation and interpretation of these data concentrated on rare earth elements. The whole rock geochemistry of these rocks is reproduced in this report with the emphasis placed on major oxide interpretation. Table 6 and Table 7 contain the geochemical data for samples collected in the Manitou Stretch area, Table 5 contains the descriptions of those samples and Figure 3 shows their location.

All the rocks that were analyzed are subalkalic (Figure 4; Irvine and Baragar 1971). Figure 5a and Figure 5b indicate that members of the Grant Lake group are largely calc-alkalic and shows a completely differentiated suite from basalt to rhyolite with andesitic compositions being the most common. Figure 6a and Figure 6b indicate that the Straw Lake metavolcanic suite is also calc-alkalic with a complete differentiation trend similar to the Grant Lake group. The Grant Lake group and Straw Lake suite are not only chemically similar but also morphologically similar and are interpreted by the author to have been derived from the same source. Edwards and Davis (1984) and Davis and Edwards (1985) indicate that the source for the Straw Lake metavolcanic rocks is portions of the Lawrence Lake Batholith adjacent to the supracrustal rocks in the Bluffpoint–Straw Lake area. This indicates to the author that the Straw Lake area was the location of a centre of calc-alkalic volcanism. Rocks of the Grant Lake group were deposited proximally to distally on the flanks of the volcanic edifice.

STRUCTURE

The dominant structural feature in the Manitou Stretch area is the Pipestone–Cameron–Manitou deformation

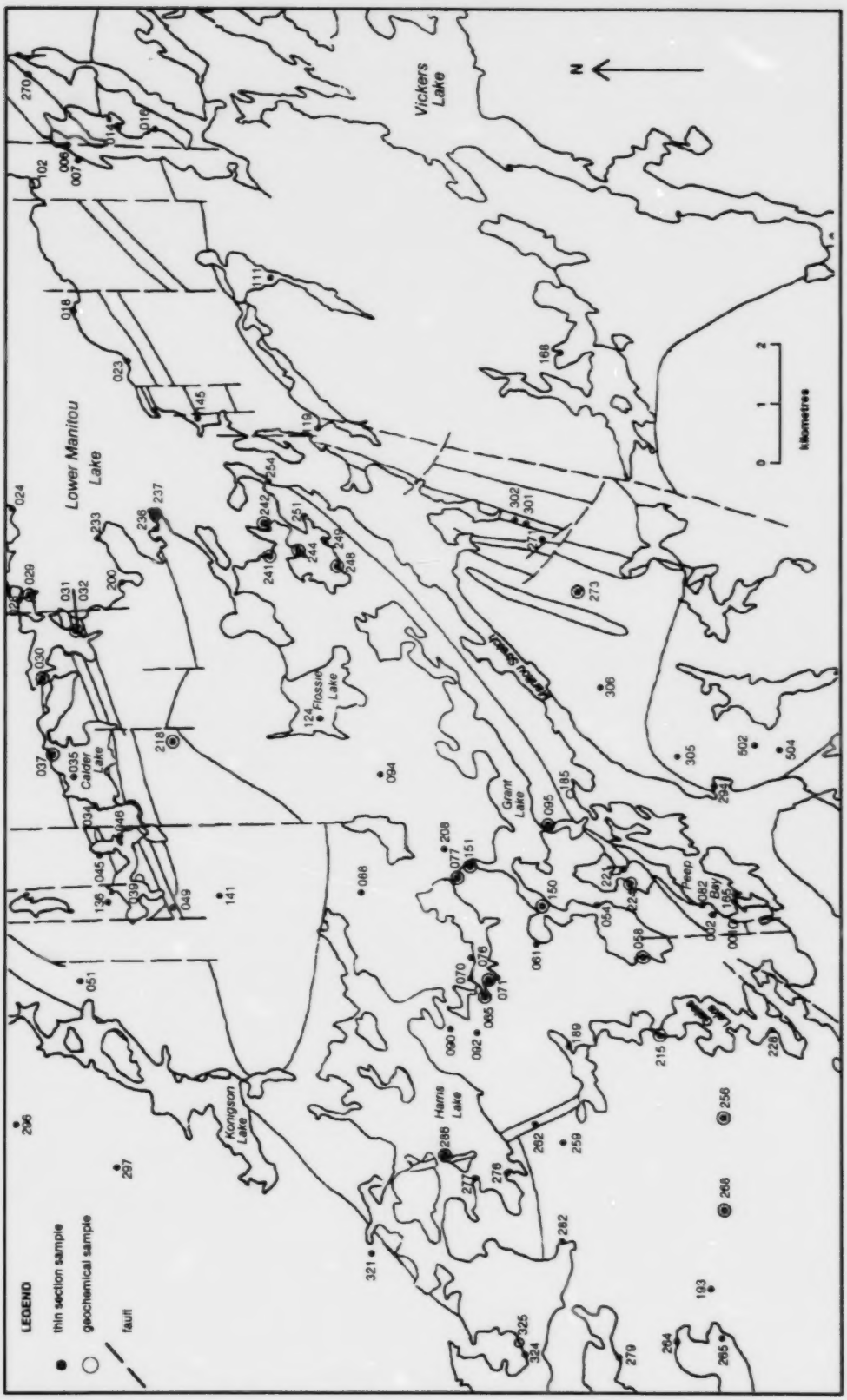

Figure 3. Location map of geochemical and thin section samples, Manitou Stretch area.

Table 5. Description of samples submitted for geochemical analysis.

Reference† Number	Sample Number	Description
1	0058*	plagioclase-phyric andesite; Grant Lake
2	0077	massive mafic flow; Napanee Lake
3	0095	massive dacite-andesite; Grant Lake
4	0150	hornblende-phyric tuff; Grant Lake
5	0151	quartz porphyry-rhyolite; between Grant and Napanee Lake
6	0215	hornblende-phyric andesite; Gates Lake
7	0224	hornblende-phyric andesite; Esther Lake (local name)
8	0241	hornblende-phyric pillowed basalt; Smoky Bay (local name)
9	0242	intermediate tuff; Smoky Bay
10	0244	dacite flow; Smoky Bay
11	0248	hornblende-phyric andesite; Smoky Bay
12	0029	feldspar crystal tuff; Upper Manitou Lake group, Lower Manitou Lake
13	0030	basalt; Blanchard Lake group, Lower Manitou Lake
14	0031	diorite to plagioclase-phyric basalt; Calder Lake sill, Lower Manitou Lake
15	0037	intermeidate tuff; Upper Manitou Lake group, Calder Lake
16	0039	quartz-phyric felsic breccia; Upper Manitou Lake group, Syndicate Lake
17	0065	pyroxenite; Napanee Lake
18	0071	quartz diorite; Napanee Lake
19	0102	massive basalt; Wapageisi Lake group, eastern shore, Lower Manitou Lake

†Numbers 1 through 11 are from the Grant Lake group
**All sample numbers are abbreviated from the standard Ontario Geological Survey sample number, e.g., 88BRB-0058*

zone which is a regional structure extending 200 km from Lake of the Woods to Dinorwic, Ontario. Within the map area, the deformation zone extends along the southeast shore of Lower Manitou Lake, along Manitou Stretch and west to Grant Lake, through the southern part of Gates Lake and west into the Vista Lake and Straw Lake areas (Smith and Stephenson 1988; Edwards 1983). The deformation zone is characterized by numerous shear zones, commonly anastomosed, which are separated by relatively undeformed blocks of rock. The shear zones are oriented east-northeasterly in the Gates Lake area and become progressively more northeasterly oriented along Manitou Stretch and Lower Manitou Lake. This change in shear zone orientation coincides with the general orientations of the granite-greenstone contacts.

Each shear zone within the deformation zone is complex and contains many structural elements. A detailed analysis of the shear zones was not undertaken; however, several general observations appear to be relevant to mineralization and the overall structure of the area. There are commonly two, and less commonly three, planar fabrics developed in the shear zones. In the Gates Lake area, the major planar fabric is oriented east-northeast and is expressed as a well developed slaty cleavage or as a fissility. A northeast-striking planar fabric, expressed as a spaced to slaty cleavage, is weakly developed and is commonly overprinted by the east-northeast cleavage. Rarely, north-striking brittle to brittle-ductile faults cut and locally offset the older planar elements.

From Peep Bay through Grant Lake to the southwest shore of Lower Manitou Lake, the major foliation in the shear zones is northeast- striking. From Flossie Lake to the southwest shore of Lower Manitou Lake, movement along the northeast-striking cleavage has transposed and juxtaposed different pyroclastic units such that they appear to be bedded. Careful examination usually reveals truncated clasts which indicate that these are fault planes rather than bedding planes. Small-scale folds, with S-style asymmetry, occurring in this area indicate that movement along these planes was sinistral.

The east-northeast-striking foliation is only weakly developed in the area from Peep Bay to the southwest shore of Lower Manitou Lake. It occurs as a spaced to slaty cleavage and is commonly sinistrally offset or rotated by the major northeast-striking foliation. Structurally competent rocks such as gabbro, massive metavolcanic flows or felsic porphyry, are commonly brittlely fractured by the east-northeast-striking foliation. These fractured rocks may localize gold mineralization.

Along the southeast shore of Lower Manitou Lake the Pipestone-Cameron-Manitou deformation zone is characterized by a large, northeast-striking shear zone which extends into the Upper Manitou Lake area where it is called the Manitou Straits fault (Blackburn 1979,1982). The east-northeast-striking fabric is locally preserved and, where seen on vertical rock exposures, is sinistrally offset by the northeast cleavage. This indicates southeast-side up vertical movement (Photo 7). A third planar fabric, expressed by a north- to northwest-striking crenulation cleavage, occurs within the shear zone. In several places, this cleavage displays minor S-style asymmetry. Locally, brittle movement along these planes resulted in north-striking faults

Linear structural elements within the shear zones of the Pipestone-Cameron-Manitou deformation zone

Table 6. Geochemistry of the Grant Lake group, Manitou Stretch area.

Compound or Element	1* 0058*	2 0077	3 0095	4 0150	5 0151	6 0215	7 0224	8 0241	9 0242	10 0244	11 0248
Major Element Oxides†											
SiO_2	55.70	49.70	65.80	61.40	72.70	54.50	58.40	62.00	56.90	61.00	58.70
TiO_2	0.59	0.96	0.60	0.57	0.12	0.76	0.74	0.71	0.64	0.56	0.65
Al_2O_3	14.30	15.80	16.50	16.10	13.70	16.90	15.90	13.50	17.30	16.40	15.60
Fe_2O_3	2.04	4.08	1.90	2.32	1.26	2.24	2.72	1.56	2.31	2.67	2.41
FeO	5.32	7.85	2.60	3.33	0.73	5.79	4.19	6.12	3.66	2.99	4.13
MnO	0.12	0.15	0.09	0.08	0.08	0.13	0.13	0.11	0.09	0.09	0.09
MgO	4.87	5.42	1.46	2.19	0.45	3.99	2.39	3.70	2.64	2.18	2.89
CaO	6.88	8.42	2.21	4.68	2.11	6.81	7.35	3.21	7.08	6.51	6.47
Na_2O	2.56	2.91	4.37	3.83	3.00	3.59	3.40	4.04	2.77	3.22	3.07
K_2O	0.22	0.02	1.26	1.14	3.03	0.85	0.08	nd¤	1.16	0.78	1.19
P_2O_5	0.11	0.11	0.18	0.11	0.05	0.14	0.14	0.16	0.12	0.11	0.11
CO_2	2.73	0.48	0.50	0.87	1.66	0.10	0.78	1.31	1.27	0.59	0.12
S	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
H_2O^+	3.67	3.69	2.27	2.53	1.08	3.03	2.74	3.26	3.23	2.66	2.54
H_2O^-	0.09	0.08	0.16	0.05	0.00	0.05	0.09	nd	0.12	0.07	0.14
LOI	5.30	3.00	2.00	2.60	2.00	2.30	2.50	3.40	3.30	2.30	2.00
TOTAL	99.20	99.30	99.90	99.20	100.00	98.90	99.10	99.70	99.30	99.80	98.10
Specific gravity	2.80	2.95	2.75	2.80	2.69	2.88	2.86	2.76	2.84	2.84	2.86
Trace Elements‡											
As	2.5	1.0	3.5	3.0	< 1.0	15.0	4.0	1.5	1.0	1.5	2.0
Au (ppb)	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ba	104.0	46.0	456.0	282.0	775.0	208.0	76.0	28.0	424.0	320.0	262.0
Co	27.0	39.0	9.0	17.0	< 5.0	26.0	21.0	24.0	19.0	18.0	20.0
Cr	234.0	123.0	< 10.0	26.0	< 10.0	115.0	21.0	99.0	29.0	28.0	76.0
Cu	52.0	73.0	< 5.0	29.0	6.0	32.0	39.0	39.0	34.0	34.0	34.0
Ni	112.0	83.0	< 5.0	26.0	< 5.0	68.0	25.0	64.0	28.0	26.0	44.0
Pb	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0
Sb	0.4	0.2	0.2	0.1	< 0.1	0.2	0.2	0.4	1.1	1.6	0.2
Zn	90.0	79.0	62.0	81.0	37.0	88.0	82.0	90.0	77.0	75.0	74.0
Be	< 1.0	< 1.0	< 1.0	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Mo	< 10.0	< 10.0	< 10.0	< 10.0	10.0	< 10.0	< 10.0.	< 10.0	< 10.0	< 10.0	< 10.0
Sc	16.0	21.0	7.0	10.0	2.0	18.0	15.0	15.0	11.0	11.0	13.0
Sr	297.0	278.0	282.0	372.0	8.0	291.0	310.0	134.0	428.0	587.0	278.0
V	123.0	184.0	42.0	97.0	5.0	147.0	135.0	109.0	111.0	106.0	117.0
Y	12.0	15.0	7.0	8.0	5.0	11.0	12.0	16.0	8.0	8.0	11.0
Nb	6.0	6.0	6.0	< 5.0	6.0	6.0	< 5.0	9.0	< 5.0	< 5.0	5.0
Rb	13.0	8.0	39.0	39.0	99.0	37.0	7.0	7.0	40.0	28.0	36.0
Zr	138.0	116.0	151.0	132.0	54.0	141.0	155.0	164.0	144.0	142.0	148.0
Th	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0
Hg (ppb)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0

* *Reference number from Table 5*
* *All sample numbers are abbreviated from the standard Ontario Geological Survey sample number, e.g., 88BRB–0058*
† *In weight percent*
‡ *In ppm, except as noted*
¤*nd – not detected*

Table 7. Geochemistry of miscellaneous rocks, Manitou Stretch area.

Compound or Element	12* 0029*	13 0030	14 0031	15 0037	16 0039	17 0065	18 0071	19 0102
Major Element Oxides†								
SiO_2	63.6	49.6	47.1	62.1	68.5	48.5	60.0	51.2
TiO_2	0.44	0.94	0.50	0.42	0.55	0.52	0.56	1.00
Al_2O_3	16.0	14.4	17.0	16.2	16.2	8.51	15.3	13.7
Fe_2O_3	1.92	3.39	3.08	2.00	0.73	1.60	1.27	2.90
FeO	2.73	8.65	6.50	2.86	1.26	10.30	5.06	10.10
MnO	0.08	0.19	0.15	0.06	0.04	0.20	0.07	0.21
MgO	1.85	7.32	7.39	2.54	0.35	16.20	2.72	5.19
CaO	3.57	10.30	12.00	5.20	1.99	6.46	3.21	7.56
Na_2O	5.20	1.14	1.16	4.47	5.16	0.50	3.37	2.60
K_2O	0.94	0.10	0.03	1.26	1.64	0.06	1.34	0.40
P_2O_5	0.14	0.08	0.01	0.14	0.14	0.08	0.13	0.10
CO_2	0.65	0.20	0.22	0.64	0.12	0.13	2.56	0.21
S	0.01	0.08	0.07	0.01	0.01	0.02	0.01	0.06
H_2O+	2.05	3.72	3.43	1.22	0.91	5.90	2.91	3.28
H_2O-	0.00	0.13	0.00	0.00	0.15	0.24	0.00	0.10
LOI	2.0	2.8	2.9	1.5	1.9	4.5	4.4	2.2
TOTAL	99.20	100.20	98.80	99.10	97.80	99.20	98.50	98.60
Specific gravity	2.73	3.10	3.04	2.78	2.70	2.94	2.73	2.97
Trace Elements‡								
As	1	3.5	11	< 1	< 1	3.5	1	< 1
Au (ppb)	< 2	2	3	< 2	< 2	< 2	6	< 2
Ba	328	26	26	374	416	2	344	118
Co	14	46	37	16	6	67	22	37
Cr	31	240	770	104	139	1030	76	< 10
Cu	14	125	133	15	5	17	169	48
Ni	16	121	10	36	8	475	37	17
Pb	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Sb	0.2	< 0.1	0.3	< 0.1	< 0.1	0.2	< 0.1	0.2
Zn	65	101	68	73	23	115	78	118
Be	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Mo	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Sc	7	35	32	9	5	21	10	30
Sr	442	113	81	478	246	20	142	149
V	66	273	207	78	72	151	84	282
Y	6	13	8	6	5	8	< 5	16
Nb	5	< 5	< 5	< 5	< 5	< 5	6	5
Rb	32	6	7	33	37	6	40	16
Zr	151	64	39	124	149	56	127	108
Th	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hg (ppb)	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5

* *Reference number from Table 5*

* *All sample numbers are abbreviated from the standard Ontario Geological Survey sample numbers, e.g., 88BRB–0058*

† *In weight percent*

‡ *In ppm, except as noted*

occur as mineral and stretching lineations, e.g., elongation of pyroclasts. From Peep Bay to Lower Manitou Lake, mineral and stretching lineations plunge steeply southwest to vertical. At Smoky Bay (local name) and along the southeast shore of Lower Manitou Lake, moderately south- to southeast-plunging mineral lineations are predominant and locally overprint southwest-plunging lineations. This suggests reactivation of vertical movement along the shear zone. This vertical movement is interpreted to be related to the intrusion of the Irene–Eltrut Lakes complex.

The Pipestone–Cameron–Manitou deformation zone effectively divides the map area into 2 major structural domains. One domain, which occurs east of the deformation zone, is underlain by rocks of the Wapageisi Lake group. It is characterized by northeast-striking structures with east-northeast-striking shearing and locally preserved lineations. Stratigraphy is homoclinally west-facing; reversals in younging were observed in only one place near the contact with the Irene-Eltrut Lakes complex. There is a narrow (200 to 300 m) contact-strain aureole developed in the supracrustal rocks around the Irene–Eltrut Lakes complex; within the aureole, structures are rotated parallel to the granite- greenstone contact. The batholith is largely undeformed, except for north- to northwest-striking faults that extend from the margins of the intrusion into the supracrustal rocks.

The second structural domain occurs west of the deformation zone. Here, northeast-striking structures are generally predominant in both the supracrustal rocks

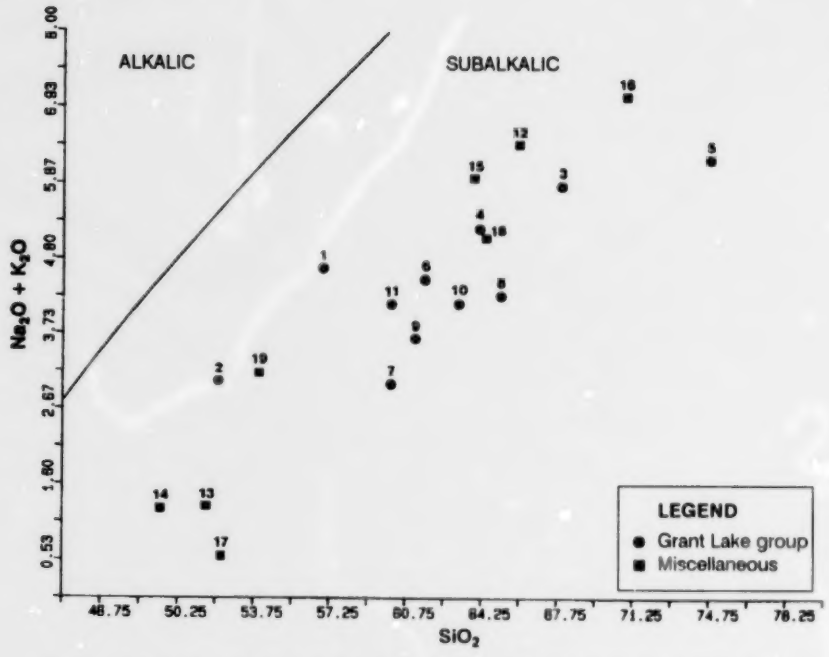

Figure 4. Alkali–silica ($Na_2O + K_2O/SiO_2$) plot for rocks listed in Table 5 and Table 6.

and the granitic rocks of the Lawrence Lake Batholith; however, east-northeast-striking structures are dominant in the Gates Lake and Calder Lake areas. The supracrustal rocks are folded, as indicated by several reversals in younging directions. Fold axes generally strike parallel to shear zones and may be transposed or terminated by north-striking faults (Calder Lake) or east-northeast-striking shear zones (Napanee Lake).

Mineral and stretching lineations are heterogeneously developed in this domain and they define a pattern apparent only at a regional scale. Along the northern boundary of the map area, lineations plunge moderately, 45° to 60°, southwest. The lineations gradually steepen, 70° to 80°, through the Neilson–Napanee lakes area until they are vertical to northwest plunging in the Davis Lake area. The lineation pattern is consistent with the observed small-scale sinistral folding pattern in the Pipestone–Cameron–Manitou deformation zone. This indicates that the northern part of the map area underwent more lateral movement than the central and southern part of the area.

Few kinematic indicators were observed in the north part of the map area; however, slickensides on a fault plane at Syndicate Lake suggest that there was upward movement of the west side. This indicates that the area around the Pipestone–Cameron–Manitou deformation zone and the central part of the map area represents a down-faulted block relative to the margins of the greenstone terrain.

The planar and linear data indicate that movement within the Pipestone–Cameron–Mantiou deformation zone and within the map area was complex. Vertical movement was predominant along the entire length of the deformation zone; however, this was overprinted in the north by minor sinistral movement. The deformation zone experienced a second, later, stage of vertical movement along the southeast shore of Lower Manitou Lake and was locally crenulated and faulted at approximately the same time. Smith and Stephenson (1988) determined that north-side up vertical movement was predominant within the Pipestone–Cameron–Manitou deformation zone in the Vista Lake area and that there was no preserved evidence for large scale transcurrent movement. The vertical movement is inferred to have been caused by emplacement of the Lawrence Lake Batholith, the Irene–Eltrut Lakes complex and the Rainy Lake complex which is south of the map area.

The Pipestone–Cameron–Manitou deformation zone, in addition to being a major structural feature, is also an important lithologic boundary. Blackburn (1982), Blackburn et al. (1985) and Edwards (1983) noted that there was no lithologic correlation across the deformation zone northeast and west of the map area. Similarly, there is no lithologic correlation across the Pipestone–Cameron–Mantiou deformation zone in the Manitou Stretch area. Deep-water mafic flows and intercalated, distally deposited, intermediate epiclastic rocks of the Wapageisi Lake group are in shear contact with shallow-water, proximally to distally deposited, intermediate metavolcanic rocks of the Grant Lake group. Younging directions face each other across a shear zone extending northeast from Gates Lake to

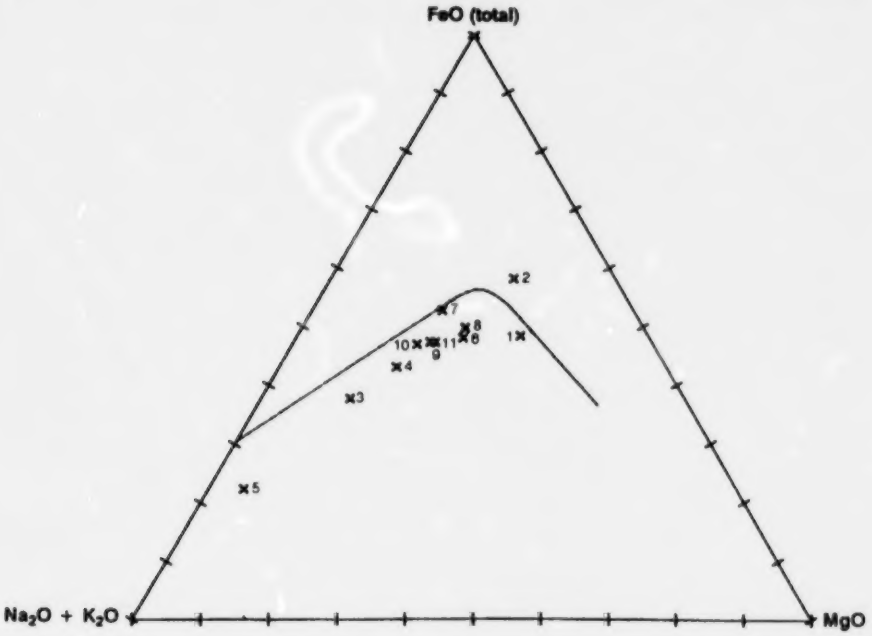

Figure 5a. AFM plot (Irvine and Baragar 1971) of rocks from the Grant Lake group. Reference numbers correspond to those found in Table 5 and Table 6.

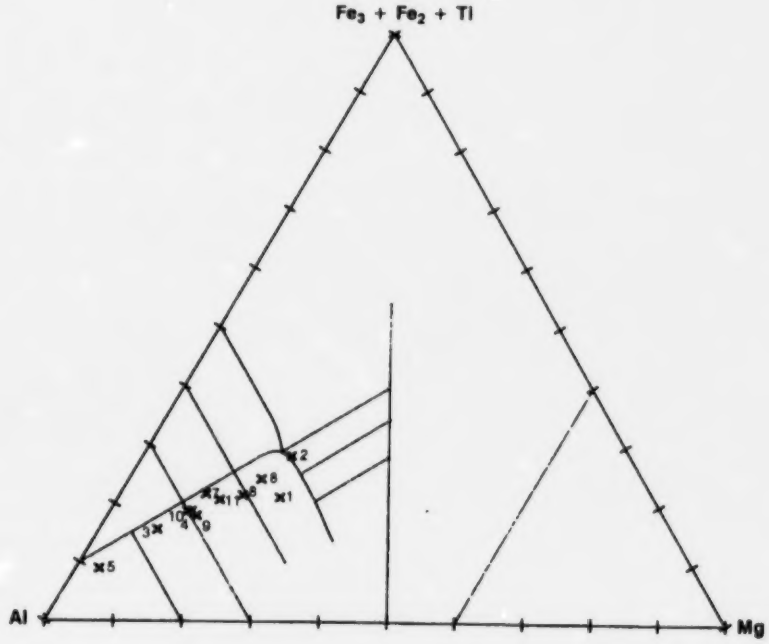

Figure 5b. Cation plot (Jensen 1976) of rocks from the Grant Lake group. Reference numbers correspond to those found in Table 5 and Table 6.

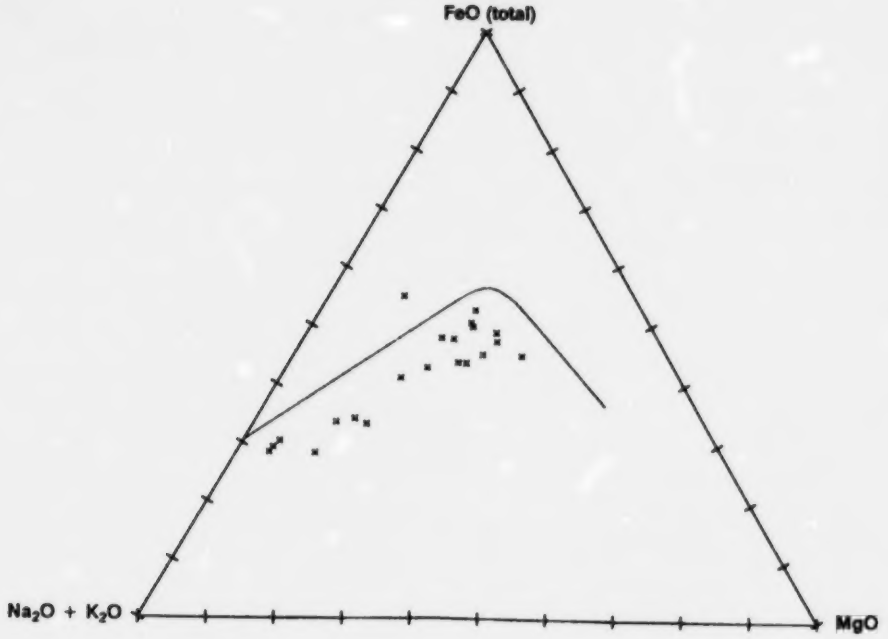

Figure 6a. AFM plot (Irvine and Baragar 1971) of Straw Lake volcanic rocks. Data taken from Edwards and Davis (1984).

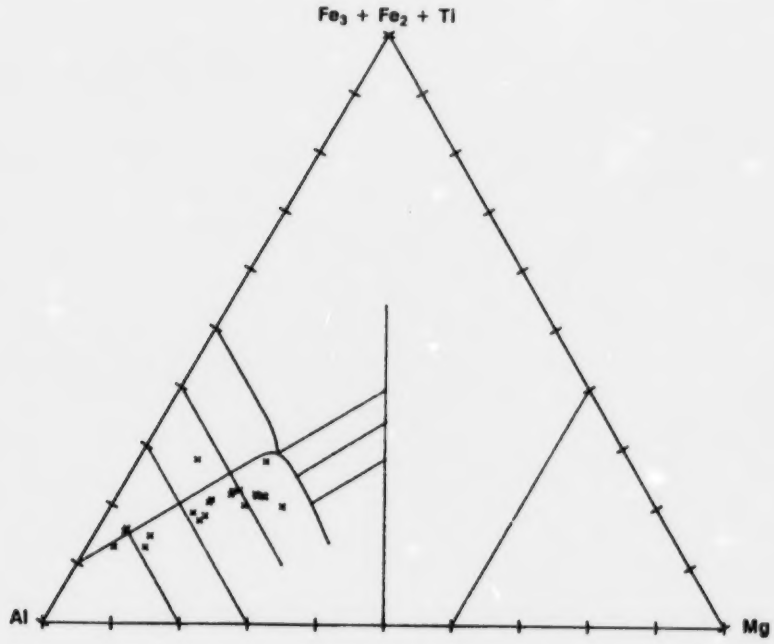

Figure 6b. Cation plot (Jensen 1976) of Straw Lake volcanic rocks. Data taken from Edwards and Davis (1984).

Photo 7. Vertical face looking northeast on a shear zone within the Pipestone–Cameron–Manitou deformation zone on Lower Manitou Lake. Southeast-side up vertical movement is apparent on this surface (*see* arrows).

Manitou Stretch, suggesting that there is a syncline here. Geological units, however, are not repeated on either side of the shear zone and detailed examination of the rocks east of the zone show several closely spaced facing reversals. It is suggested that the Wapageisi Lake group was structurally juxtaposed to the Grant Lake group and fold axes became more tightly spaced, modified and transposed by progressive shear deformation until they merged within the deformation zone. This style of deformation is also observed in the Michipicoten greenstone belt (Heather and Buck 1988).

All rocks in the map area have been deformed by north-striking brittle to brittle-ductile faults, several of which occur across the northern boundary of the map area and are particularly evident at Aronson Lake and in the Calder Lake area. Here, the faults brittlely deformed the supracrustal and granitic rocks with up to 550 m of left-lateral displacement. A north- to northeast-striking sinistral fault extends 14 km from Eyelid Lake to Vista Lake. This structure displays brittle faulting along the granite-greenstone contact at Eyelid Lake, narrow 1 to 5 m wide, mylonite
-cataclasite zones in the Irene–Eltrut Lakes complex in the Kahabeness Lake area, and a wide shear zone system in the metavolcanic rocks at Vista Lake (Smith and Stephenson 1988). This along-strike change is attributed to different levels of crustal exposure and to splaying of the structure. The north-striking faults are the youngest structures in the map area and were developed after the marginal phases of the Irene–Eltrut Lakes complex crystallized.

METAMORPHISM

Supracrustal rocks in the Manitou Stretch area have generally attained lower greenschist facies metamorphism (Winkler 1979). In most mafic metavolcanic rocks, the typical mineral assemblage is chlorite + epidote + actinolite. In intermediate metavolcanic rocks the typical mineral assemblage is chlorite + epidote + sericite ± albite ± actinolite.

Amphibolite facies contact metamorphic aureoles occur around the granitic intrusions and around the Calder Lake sill. Mafic metavolcanic rocks metamorphosed to amphibolite facies are characterized by the mineral assemblage epidote + blue-green amphibole ± chlorite. Intermediate metavolcanic rocks metamorphosed to amphibolite facies are characterized by the mineral assemblage epidote + biotite + amphibole ± chlorite ± feldspar. Garnet occurs in the matrix of intermediate metavolcanic rocks in the contact metamorphic aureole around the Calder Lake sill.

Migmatite, formed extensively around the Lawrence Lake Batholith, lacks well defined melanosome and leucosome components, which indicates that the migmatite was formed by injection rather than *in situ* partial melting (Brown 1973). Diagnostic metamorphic minerals are absent in the migmatite. The absence of pelitic metasedimentary rocks and, as a result, diagnostic metamorphic minerals, greatly hinders more detailed investigations of metamorphic conditions in the map area.

ALTERATION

Hydrothermal alteration, typically in the form of widespread, brown carbonate mineralization, has affected several areas of the supracrustal rocks. Brown carbonate occurs within these alteration zones as pods, stringers and veins and as grains pervasively disseminated throughout the rocks. This type of alteration is most common within shear zones of the Pipestone–Cameron–Manitou deformation zone where it may be accompanied by silicification and various amounts of sulphide mineralization.

Silica alteration occurs as veins, stringers and pervasive flooding of the rock. Quartz veins and stringers are common throughout the map area; where they occur within shear zones and are accompanied by sulphide mineralization and carbonate alteration, they may be auriferous. Within the Pipestone–Cameron–Manitou deformation zone, pervasive silicification is heterogeneously developed in the Gates Lake and Peep Bay areas and is accompanied by sulphide mineralization and gold mineralization (*see* "Economic Geology").

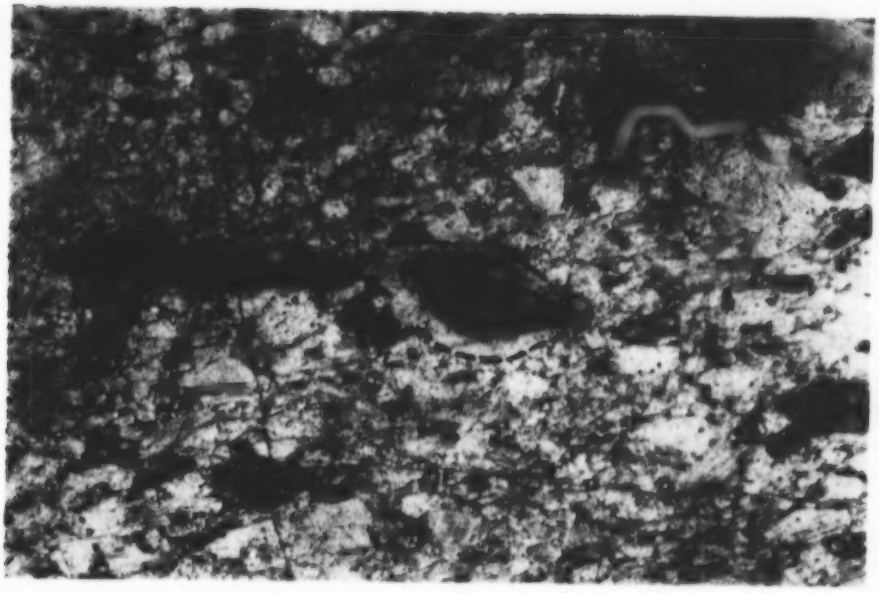

Photo 8. The silicified pyroclastic deposit of the Grant Lake group on Harris Lake is part of a 5 km² area affected by partial to total silicification. The pencil (14 cm long) points to the silicified rim of a clast (dashed line) and the unaltered core.

An area (about 5 km²) of intermediate pyroclastic rocks and minor flows has undergone pervasive silicification at Harris Lake. The intensity of silicification ranges from replacement of the matrix of pyroclastic deposits to total destruction of all primary features, in which case the rock resembles chert. Commonly, matrix and fragments display a moderate degree of silicification which still permits recognition of the protolith (Photo 8). Silicification does not affect a large, northwesterly-striking, postvolcanic ultramafic-mafic dike; nor does it affect a suite of buckled basaltic dikes intruding the silicified metavolcanic rocks. This is interpreted as evidence for pre-deformation introduction of the silica, possibly shortly after the deposition of the metavolcanic rocks and possibly related to the intrusion of the Lawrence Lake Batholith. This type of silica flooding is common in the Abitibi greenstone belt, most notably in the Rouyn–Noranda base metal camp (Lydon 1988; Knuckey et al. 1982).

SUMMARY OF GENERAL GEOLOGY

Davis et al. (1988) proposed a model for the tectonic evolution of the western Wabigoon Subprovince constrained by U-Pb dating of zircon and titanite.

Geological mapping in the Manitou Stretch area and the Vista Lake area (Smith and Stephenson 1988) has generated valuable empirical data which can be interpreted and compared with the results of Davis et al. (1988). These data, combined with the results of previous work (*see* "Previous Geological Work"), have important regional implications for the present area of investigation in western Wabigoon Subprovince.

Davis et al. (1988) envisaged early volcanism in the Wabigoon Subprovince originating in an ensimatic spreading ridge environment prior to 2775 Ma. This volcanism was predominantly of mafic composition and formed in a deep water environment; it is comparable to mafic plain sequences described by Thurston and Chivers (1990). The lower part of the Wapageisi Lake group, exclusive of the Etta Lake formation, is interpreted by the author to represent this paleoenvironment. It has a minimum age of 2755 million years (Davis et al. 1982), which places it amongst the oldest metavolcanic rocks in this part of the western Wabigoon Subprovince.

One of the more important features in the map area is the recognition that the Grant Lake group represents a shallow water to subaerially deposited, calc-alkalic metavolcanic sequence. Similar sequences occur at Lake of the Woods (Morrice and MacMaster 1987), in the Sandybeach Lake area (Berger 1989) and at Straw Lake (Edwards 1983). This indicates that shallow water, calc-alkalic Archean volcanism was widespread in the western Wabigoon Subprovince. These sequences are morphologically and chemically similar to modern-day island arc volcanics rocks (Morrice and MacMaster 1987) and are comparable to mafic-felsic greenstone sequences described by Thurston and Chivers (1990). Davis et al. (1988) indicate that these calc-alkalic sequences were formed between 2710 and 2745 Ma, are contemporaneous with granitoid intrusions such as the Lawrence Lake Batholith, and originated by subduction and partial melting of ensimatic crust in an island arc environment.

In the map area, deformation is clearly postvolcanic and movement was predominantly vertical as demonstrated in the Pipestone–Cameron–Manitou deformation zone. The intrusion of the granitic batholiths is the inferred cause of the deformation, as structural patterns in the supracrustal rocks are subparallel to their contacts. Davis et al. (1988) indicate that regional deformation occurred in the western Wabigoon Subprovince between 2700 and 2710 Ma, and was characterized by early nappe and thrust movement and late compressional isoclinal folding. The Manitou Stretch area has recorded only the late-stage structural event.

The Pipestone–Cameron–Manitou deformation zone is the major locus for gold in the map area; and mineralization is syn- to postdeformational. Gold deposits associated with this structure involve: the Gaffney deposit and the old mine site of Goldrock, to the northeast; and Straw Lake and Cameron Lake, to the west. Therefore, the Pipestone–Cameron–Manitou deformation zone is an economically important regional structure and a prime exploration target.

Economic Geology

Gold has been the most actively sought economic commodity in the map area. Carter (1901, 1904) reported that the earliest exploration activities in the map area resulted in the discovery of the Sairey Gamp and Gold Standard occurrences near Napanee Lake and the Gold Standard occurrence at Neilson Lake. Extensive exploration in the 1930s and 1940s resulted in the discovery of the Beehive–Gaffney gold occurrences, northeast of the map area, and the Straw Beach Lake gold mine, west of the map area (Thomson 1934). During this time, gold mineralization was discovered by Birch Bay Gold Mines, Limited at Gates Lake and Peep Bay (Resident Geologist's office, Kenora).

Renewed interest in the Gaffney occurrence sparked extensive exploration in the map area in the early 1980s. Sparton Resources Inc. was most active, exploring the Gates Lake–Peep Bay gold showings. During the 1988 field season, exploration for gold was renewed by Homestake Mineral Development Company.

Concerted base metal exploration has been minimal in the map area. The Canadian Nickel Co. tested several selected geophysical anomalies by diamond drilling from 1969 through 1971. Their exploration efforts concentrated on testing portions of the Etta Lake formation and parts of the mafic metavolcanic rocks correlative with the Blanchard Lake group. Only trace amounts of copper and zinc were encountered, and based on this information, it appears that these rocks have low potential for volcanogenic base metal deposits. The author believes that the felsic- intermediate pyroclastic rocks underlying the Calder–Syndicate lakes area and the silicified pyroclastic rocks at Harris Lake have greater potential for base metal mineralization.

Gold

Gold mineralization is structurally controlled and occurs in 3 environments. The Gates Lake–Peep Bay showings, representing one of these environments, occur in silicified and carbonatized shear zones and fractures within the Pipestone–Cameron–Manitou deformation zone. Structurally competent, intermediate to mafic flows and synvolcanic intrusions are preferred as hosts over pyroclastic deposits. Gold is accompanied by pyrite, arsenopyrite and, less commonly, stibnite.

In the second mineralization environment, gold may occur within narrow shear zones of limited strike extent near the "granite-greenstone" contacts. Examples of this mineralization environment can be found south of Kahoeness Lake and in shear zones parallel to, but separated from, the Pipestone–Cameron–Manitou deformation zone. Mineralization and alteration are confined within the shear zones which are generally less than 5 m wide. The Gold Standard occurrences and the Sairey Gamp occurrence are examples of this environment.

Examples of the third environment occur at Aronson Lake and along the northeast shore of Manitou Stretch. At this location, sulphide mineralization and geochemically anomalous values are contained in sheared basalts and cherty metasediments where they are cut by late, north-striking faults.

Copper

Copper mineralization occurs in structurally controlled quartz veins within the Manitou Stretch area and may accompany gold mineralization. Although 1.5% and 1.1% copper was returned from 2 of these veins, they are generally too limited in size to be economically profitable (Table 8).

Numerous samples from known mineral showings and from other prospective areas were collected by members of the crew during the field season and were analyzed by the Geoscience Laboratories, Ontario Geological Survey (Table 8; Figure 7). Other assay values referred to in this section were obtained from reports, filed for assessment work credit with the Assessment Files Research Office, Ontario Geological Survey, and from the Resident Geologist's office, Kenora.

Table 9, a summary of the exploration history of the Manitou Stretch area, was compiled from Geological Data Inventory Folio 320 (Ontario Geological Survey 1986) and reports filed for assessment work credit. (AFRO, Toronto; Resident Geologist's office, Kenora). Readers are referred to these sources for detailed accounts of previous work. The following section reports on data obtained by the field party during the 1988 field season and offers observations and interpretations of the properties.

DESCRIPTION OF PROPERTIES

BIRCH BAY GOLD MINES, LIMITED

(Gates Lake Occurrence)

In 1941, prospectors working for Birch Bay Gold Mines, Limited (Figure 7, Property 1) discovered gold at Gates Lake (*The Canadian Mines Handbook 1941*, p.23). Birch Bay Gold Mines, Limited, in partnership with Goldale Mines, Limited, staked 18 unpatented mining claims and explored them between 1941 and 1944. Three areas of gold mineralization were discovered: 2 in the Gates Lake area (Gates Lake occurrences), and 1 west of Peep Bay which is discussed in greater detail under Sparton Resources Inc.

The Gates Lake occurrence (Figure 7, Property 4) was explored via several surface trenches and approximately 1150 m of diamond drilling in 6 holes (assessment files, Residents Geologist's office, Kenora; *The Canadian Mines Handbook 1946*, p.39,40). The best results were reported from trenches on the "centre zone"

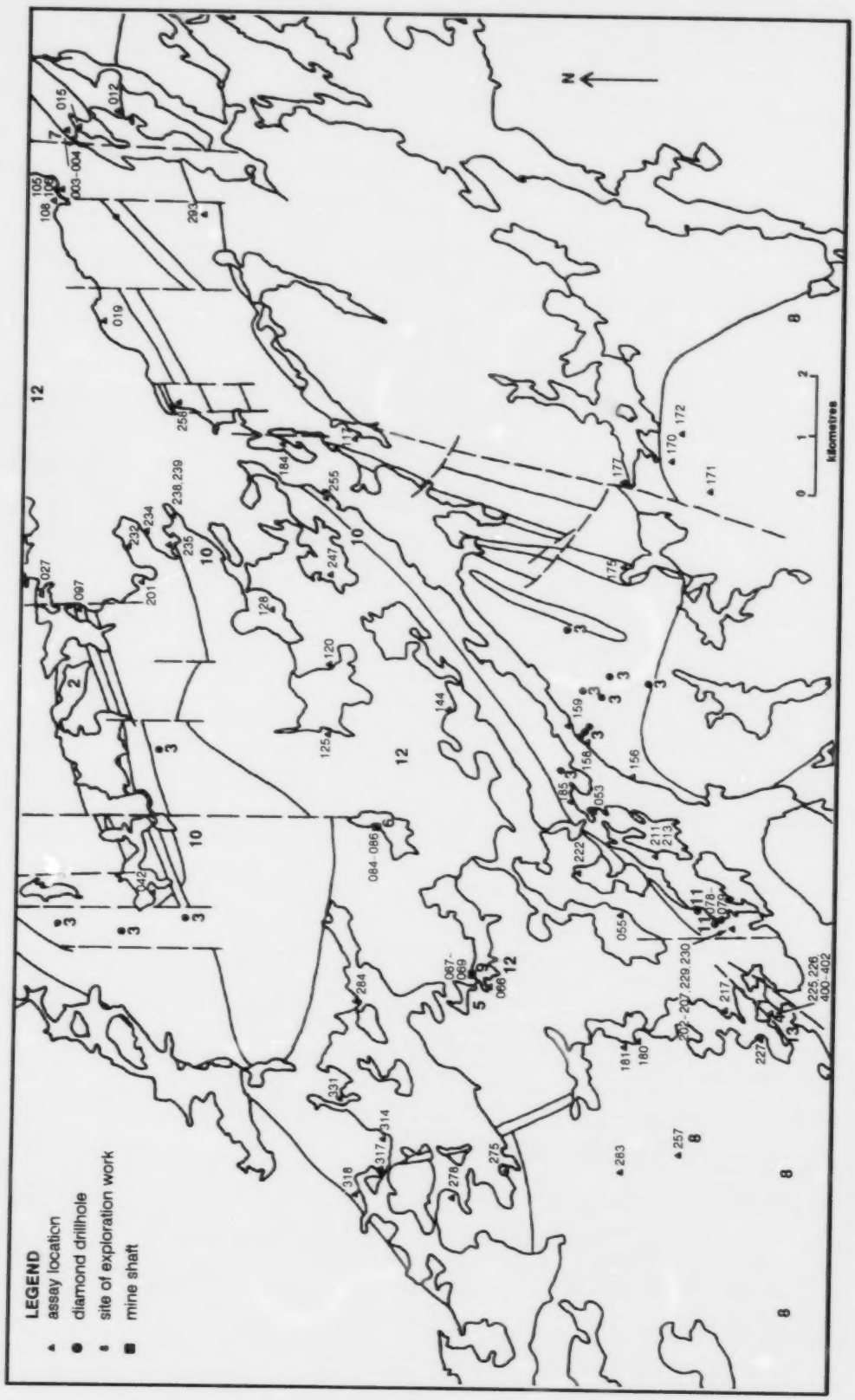

Figure 7. Location map of properties and assay samples.

where 0.16 ounce Au per ton over 10 feet was encountered. Gold assays from the diamond drilling were not reported; however, up to 7% antimony was encountered (assessment files, Resident Geologist's office, Kenora; Beard and Garrett 1984). No further work was carried out and the claims were allowed to lapse. In 1983, the area was staked by R. Van Enk of Norontex Exploration Limited (Figure 7, Property 13) but no new work was reported. In 1988, Noranda Exploration Company, Limited (Figure 7, Property 8) submitted airborne magnetometer and VLF-EM surveys covering the Gates Lake occurrence, for assessment work credit. Most recently, the area was staked by R. Fairservice (Prospector, Dryden, Ontario) who optioned the claims to Homestake Mineral Development Company (Brian Christie, Homestake Mineral Development Company, personal communication, 1988). Homestake completed a ground magnetometer survey and a reconnaissance soil and rock geochemical sampling program in the summer of 1988 and the winter of 1989 (Brian Christie, Homestake Mineral Development Company, personal communication, 1989). The best results obtained by the geochemical sampling returned 21 950 ppb gold from a trench in the "centre zone". Other anomalous gold values between 420 ppb and 7380 ppb were also encountered in the trenches. Arsenic values up to 99 937 ppm (~10%), antimony values up to 102 ppm and bismuth values up to 21 ppm accompany the gold.

The Gates Lake occurrence lies within a portion of the Pipestone–Cameron–Manitou deformation zone where numerous structural complications occur. Mapping by the field crew indicates that east-northeast-striking shearing is very prominent and effects all rock types in the southern part of the Gates Lake area. Narrow, discrete, northeast-striking shear zones and north-striking fractures and faults occur locally and appear to transect the east-northeast fabric. Rock units are transposed and displaced by these later structures and the north-striking structures are known to transect gold mineralization.

Trenches at the Gates Lake occurrence, specifically in the "centre zone", were located, examined and sampled by the author (Figure 8; Table 8). Trenches at the Gates Lake zone (Figure 8) were not located.

The "centre zone" (Figure 8) extends over 300 m within hydrothermally altered, sheared and fractured gabbro. The hydrothermal alteration is characterized by widespread iron carbonate deposition, within which zones of pervasive silicification accompanied by pyrite and coarsely crystalline arsenopyrite are heterogeneously developed. Gold commonly occurs within the silicified zones and to a lesser extent, in the carbonatized rocks where it is accompanied by sulphide mineralization. Quartz veins are not abundant and limited sampling (Table 8, sample 401) indicates they are not gold-bearing. Antimony was reported from the diamond-drill program (assessment files, Resident Geologist's office, Kenora); however, stibnite was not observed by the author and the assays detected antimony values only slightly above background (Table 8).

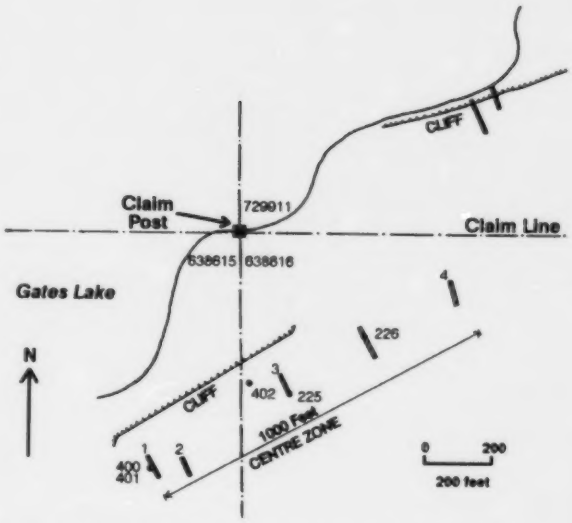

Figure 8. Location map of the Gates Lake gold–antimony occurrence; modified after Norontex Exploration Ltd., 1984.

Identification of the host rock is hampered in most places by the alteration and the shearing. In most cases, only a slightly magnetic mafic schist was identified although intermediate pyroclastic deposits were identified to the north of the showing. In a couple of places in the "centre zone", coarse-grained, leucocratic gabbro was observed. This rock is similar to those observed by the author at Peep Bay, and reported to be present at the Gaffney deposit located northeast of the map area (C.E. Blackburn, Ministry of Northern Development and Mines, personal communication, 1988).

The gabbro appears to be preferred over pyroclastic deposits as the host for gold mineralization. This is ascribed to the structural competence of the gabbro which permits a greater amount of fracturing than in the pyroclastic rocks, thus providing open space into which mineralized fluids deposited gold. A positive aeromagnetic signature coincides with the gabbro at Gates Lake, and serves as a broad geophysical target within which gold may occur (Geological Survey of Canada 1988a, 1988b). Future exploration should concentrate on mapping the gabbro and searching for silicified zones within it.

BLACK GOLD OIL & GAS LTD.

In 1985, Black Gold Oil & Gas Ltd. (Figure 7, Property 2) carried out ground VLF-EM and magnetometer surveys along north-trending grid lines on a group of claims in the Calder Lake area. All electromagnetic anomalies were attributed to conductive overburden and no further work was carried out (Table 9).

Mapping during the present survey indicates that the Calder Lake area is underlain by intermediate to felsic, pyroclastic and epiclastic rocks correlative with the Upper Manitou Lake group (Blackburn 1976, 1982), and by mafic metavolcanic rocks tentatively correlated with the Blanchard Lake group (Blackburn 1976, 1982).

Table 8. Assay results for the Manitou Stretch area.

Sample Number	Au (ppb)	Ag (ppm)	Cu	Zn	As	Sb	Hg (ppb)	W	Other	Comments
0003*	13	< 2	252	1610	26	0.4				rusty basalt at contact with chert; Aronson Lake
0004	730	2	265	540	130	0.3				chert and intermediate tuffs with pyrite; Aronson Lake
0012	< 2	< 2			2			< 50		sheared quartz-feldspar; 1% pyrite and Fe-carbonate; Aronson Lake
0015	16	< 2			6	0.2		< 50		pyritic felsite with Fe-carbonate; Aronson Lake
0019	< 2	< 2			44	0.6		< 50		felsite dike; Lower Manitou Lake
0027	< 2	< 2						< 50		quartz vein in quartz porphyry; north shore, Lower Manitou Lake
0042	< 2	< 2			3.5	0.1		< 50		quartz-tourmaline vein in felsic tuff-breccia; Syndicate Lake
0053	6	< 2	120	53						shear zone with Fe-carbonate, trace pyrite; Manitou Stretch
0055	< 2	< 2						< 50		quartz vein in intermediate pillow breccia; Grant Lake
0066	6	< 2	12	135	90	nd¤			420 ppm Ni	pyroxenite, 3 ppb platinum, < 1 ppb palladium; northwest shore, Napanee Lake
0067	< 2	< 2			2	nd		< 50		dump material; north side of Napanee Lake (Sairey Gamp shaft?)
0068	< 2	< 2			2.5	nd		< 50		quartz-carbonate-sericite schist; Napanee Lake
0069	< 2	< 2			3	nd		< 50		as above
0078	< 2	< 2	33	56	10	0.7		< 50		chlorite-Fe-carbonate schist, 5% pyrite; southwest Peep Bay
0079	20	< 2	125	93	170	1.3		< 50		silicified Fe-carbonate schist with pyrite; southwest Peep Bay
0084	1.37 oz/ton	29	1.52%	138	85	0.2		< 50		quartz-chalcopyrite vein material from dump; Gold Standard Inc. shaft
0085	55	< 2	22	10	4.5	nd		< 50		quartz vein, no chalcopyrite, from dump; Neilson Lake
0086	50	< 2	386	60	5.5	nd		< 50		Fe-carbonate wall rock, with pyrite and trace chalcopyrite from dump
0097	< 2	< 2			2			< 50		quartz vein in gabbro; northwest shore, Lower Manitou Lake
0105	< 2		96		237					pyrrhotite pods in mafic pillow breccia; northeast side, Lower Manitou Lake
0106	10	< 2				0.2		< 50		quartz vein and rusty wall rock; northeast side, Lower Manitou Lake
0108	27	9	1.14%	173	13	0.3			36 ppm Ni	quartz-carbonate vein and pyrite in mafic flow; northeast side, Lower Manitou Lake
0117	2	< 2	233	179	24				24 ppm Ni	Fe-carbonate mafic schist, trend 020°; Eyelid Lake
0120	< 2	< 2	82	110	5.0	0.2				Fe-carbonate-chlorite schist; Flossie Lake
0125	< 2	< 2	30	94						rusty intermediate lapilli tuff; Flossie Lake
0128	< 2	< 2	21	149	12	0.4				Fe-carbonate-sericite intermediate schist; Phairs Lake
0144	< 2	< 2	23	98	18					Fe-carbonate-sericite intermediate schist; Grant Lake
0156	8	< 2			84					Fe-carbonate-sericite mafic schist; east side, Manitou Stretch
0158	< 2	< 2			23					pyritic, cherty metasediments; east side, Manitou Stretch
0159	< 2	< 2	30					< 50		quartz vein + mafic schist, 2% pyrite; east side, Manitou Stretch
0170		< 2	48	143		2				rusty pillow selvadges; south of Kahabeness Lake
0171	18		535	118		1				sulphide pods in pillow selvadges; south of Kahabeness Lake
0172	685	2								10 cm quartz vein with epidote-pyrite-sericite; south of Kahabeness Lake
0175	< 2	< 2	70	92	3.5	0.3				rusty basaltic dike with trace pyrite; north shore, James Lake
0177	< 2	< 2	< 5	29	1					mylonitic granodiorite; west side, Kahabeness Lake
0180	< 2	< 2	< 5	108	4					quartz and pyrite pods in intermediate flows; north of Gates Lake
0181	4	< 2	40	91	58					carbonate-sericite-pyrite pods in intermediate pillow breccia; north of Gates Lake
0184	< 2	< 2			17					chlorite-Fe-carbonate mafic flow with pyrrhotite; northeast side, Manitou Stretch
0185	< 2	< 2			89					mafic tuff and schist between Manitou Stretch and Grant Lake
0201	2	< 2			13	0.1				sericite-chlorite ± carbonate intermediate schist; west shore, Lower Manitou Lake
0202	2	< 2	91	103	90	1.4	17			northwest end, trench 1, Sparton Resources Inc.; Peep Bay
0203	80	< 2	< 5	44	1.3%	3.5	8			gabbro-mafic flow, 15-20% arsenopyrite, 10% pyrite; 6 m southeast of sample 202

Table 8. continued

Sample Number	Au (ppb)	Ag (ppm)	Cu	Zn	As	Sb	Hg (ppb)	W	Other	Comments
0204	840	< 2	12	36	2.3%	8.7	24			silicified zone with pyrite, arsenopyrite, chalcopyrite, 25% sulphides; 12.7 m southeast of sample 202
0205	140	< 2	18	54	6800	3.3	10			silicified zone with arsenopyrite > pyrite, Fe-carbonate common; 34.5 m southeast of sample 2021
0206	17	< 2			205	0.5				barren quartz vein from zone; 34.5 m southeast of sample 202
0207	1540	< 2	26	33	2.55%	13.1	22			representative grab sample from trench 4; Sparton Reosurces Inc.
0211	< 2	< 2				1.7	15			quartz-carbonate vein plus sericite from pit; east side, Peep Bay
0212	3	< 2				0.8	12			quartz-carbonate vein main pit; east side, Peep Bay
0213	2	< 2	81	71	150	3.4	28			Fe-carbonate schist wall rock, 2% pyrite, quartz "eyes"
0217	< 2	< 2			120	0.7				Fe-carbonate mafic schist; east side, Gates Lake
0222	< 2	< 2			4.5	0.6				quartz-carbonate schist; north shore of Esther Lake
0225	265	< 2			1.65%	9.7	6			silicified and carbonatized gabbro with 30% pyrite and arsenopyrite, trench 3; Gates Lake
0226	165	< 2			480	4.3	7			silicified and carbonatized gabbro with 10–20% pyrite and arsenopyrite; trench at Gates Lake
0227	2	< 2			350	1.3	7			green-mica-bearing, carbonatized felsite; Gates Lake
0229	155	< 2			820	1.3	6			45 cm quartz vein in trench 5, Sparton Resources Inc.; Peep Bay
0230	22	< 2			1500	2.9	5			silicate and carbonate schist wallrock, trench 5, up to 20% pyrite and arsenopyrite
0232	< 2	< 2								4 m by 45 cm barren quartz vein; west shore, Lower Manitou Lake
0234	< 2	< 2	30	26	19	0.1				sheared quartz feldspar in deformation zone, hematized, no sulphides; west shore, Lower Manitou Lake
0235	< 2	< 2	< 5	16	17	0.2				sheared, carbonate- and sericite-rich quartz porphyry
0238	28	< 2	< 5	51	13	0.6	6			pyrite and carbonate quartz veins in quartz-feldspar porphyry dike in deformation zone; Lower Manitou Lake
0239	< 2	< 2								quartz-carbonate vein, trace pyrite; same location as above
0247	< 2	< 2	52	44					36 ppm Ni	intermedite tuff with 10–15% pyrrhotite; island in Smoky Bay (local name)
0255	36	2	55	83	68	22				pyrite in sheared cherty material; northwest side, Manitou Stretch
0257	< 2	< 2			7.0	5				pyritic shear zone in intermediate flow; west of Gates Lake
0258	115	3			380					sheared pyritic chert; northeast side of Manitou Stretch
0275	8	< 2	141	36	2.5					silicified basalt with 2% pyrrhotite; south shore, Harris Lake
0278	< 2	< 2	7	64	1.0					rusty silicified zone in basalt, trace pyrite; east side, Harris Lake
0283	< 2	< 2			3.5					quartz carbonate vein, no sulphides; south of Harris Lake
0284	< 2	< 2	98		1.5					pyritic quartz vein; northeast shore, Harris Lake
0293	7	< 2			6.0					quartz vein with trace pyrite; west of Aronson Lake
0314	< 2	< 2	5	23	1.0					pyritic gossan in basalt; north shore, Harris Lake
0317	< 2	< 2	30	18	2.5					pyritic gossan; east of sample 314 location
0318	7	< 2	16	62	8.5					tonalite at contact with "greenstone"; northwest shore, Harris Lake
0331	< 2	< 2	43	91	4.5					rusty mafic crystal tuff; north shore of Harris Lake
0400	230	< 2			5500	3.8			0.5 ppm Bi	silicate zone in gabbro, trench 1; Gates Lake showing
0401	< 2	< 2			100	0.3			Bi nd	quartz vein material from trench 1; Gates Lake showing
0402	270	< 2			4.0%	10.3			1.4 ppm Bi	arsenopyrite, pyrite in silica-carbonate gabbro, 30 m west of trench 3; Gates Lake

**All sample numbers are abbreviated from the standard Ontario Geological Survey sample numbers, e.g., 88BRB-0003.*
nd - not detected

Table 9. Exploration chart of the Manitou Stretch area.

COMPANY	PROPERTY LOCATION	YEAR	WORK	SIGNIFICANT RESULTS
Birch Bay Gold Mines, Limited	Gates Lake–Peep Bay	1940s	trenching and drilling	visible gold reported, 0.16 ounce Au per ton over 10 feet; 6 diamond-drill holes, locations unknown
Black Gold Oil & Gas Ltd.	Calder Lake area	1985	ground magnetometer and VLF-EM surveys	two possible ground conductors
Canadian Nickel Co.	scattered throughout the area	1969–71	14 diamond-drill holes, totalling 592.7 m	spotty chalcopyrite and sphalerite mineralization
Gold Standard Mining Co.	Napanee Lake (Sairey Gamp)	1900	45.7 m shaft with 6.1 m drift	no gold values reported on 0.4 m quartz vein
Gold Standard Mining Co.	Neilson Lake	1902	28.9 m shaft with 33.5 m drift	1.8 ounces Au per ton from dump (Thomson 1934)
Jalna Resources Ltd.	Aronson Lake area	1985	AM and AEM, trenching	maximum 350 ppb gold over 2.5 feet (cf. assay-0004)
Noranda Exploration Company, Limited	southeast corner of map area	1973	AM and AEM, ground EM and magnetometer surveys	one anomaly from airborne surveys
Noranda Exploration Company, Limited	west of Gates Lake	1984	geology survey lithogeochemistry ground magnetometer and IP surveys	a few elevated Hg anomalies
Noranda Exploration Company	Gates Lake to west boundary	1988	AM and AEM surveys	useful for interpretation
Sairey Gamp Occurrence	Napanee Lake north shore	1900	22.9 m shaft with 7.3 m drift	no gold values reported on quartz vein
Silver Lake Resources Inc.	Manitou Stretch to Syndicate Lake	1984–86	geology survey lithogeochemistry ground magnetometer and VLF-EM surveys soil geochemical survey	0.014 ounce Au per ton in altered basalt
Sparton Resources Inc.	Peep Bay area	1984–85	geology survey, trenching, lithogeochemistry ground magnetometer and VLF-EM surveys	0.42 ounce Au per ton over 1 m in trench 1 0.21 ounce Au per ton over 1 m in trench 4 0.15 ounce Au per ton, 1.4 ounces Ag per ton over 2 m in trench 6, 2 diamond-drill holes totalling 153.9 m
Sparton Resources Inc.	Mister–Missus Lakes area	1984–85	prospecting, lithogeochemistry	74 ppb Au–highest value
Teck Explorations Limited	Lower Manitou Lake	1983	ground magnetometer and VLF-EM surveys	two bedrock conductors located
Teck Explorations Limited	Davis Lake to Napanee Lake	1983	ground magnetometer and VLF-EM surveys	several ground conductors
Teck Explorations Limited	Flossie Lake area	1983	ground magnetometer and VLF-EM surveys	several ground conductors
Van Enk, R.	Gates Lake	1983	summary geological report	no additional results to prior work

A syn- to postvolcanic gabbroic sill, the Calder Lake sill, intrudes the metavolcanic rocks and several north-striking, late stage faults disrupt the stratigraphy. There is no record of exploration prior to the work by Black Gold Oil & Gas Ltd. and in the opinion of the author, the base metal potential of this section of the map area has not been fully explored.

CANADIAN NICKEL CO.

From 1969 through 1971, the Canadian Nickel Co. (Figure 7, Property 3) carried out diamond drilling on selected airborne electromagnetic anomalies throughout the map area, in an effort to discover economic base metal deposits (Table 9). Ten of 14 drill holes were located north of the Bretz Lake stock, near Manitou Stretch, within units correlative with the Wapageisi Lake group (Blackburn 1982). Erratic, uneconomic sulphide mineralization or graphite was encountered in each of the drill holes, and in several of the holes drilled in rocks correlative with the Etta Lake formation (Blackburn 1976, 1982).

One diamond-drill hole, sunk south of Calder Lake, encountered disseminated magnetite and pyrite in coarse-grained mafic metavolcanic flows and/or gabbros correlative with the Blanchard Lake group.

Three diamond-drill holes were sunk west of Syndicate Lake. The southern-most hole encountered graphitic and pyritic intermediate metavolcanic rocks correlative with the Upper Manitou Lake group (Blackburn 1976, 1982). The other drill holes encountered gabbro, basalts and mafic schist. The northern-most hole encountered up to 70% combined pyrite and pyrrhotite with 1% chalcopyrite and sphalerite over 0.7 m within mafic schist.

None of the diamond-drill holes were located by the field crew; however, several traverses were carried out in the areas explored by the Canadian Nickel Co. In general, the Canadian Nickel Co.explored areas dominated by mafic metavolcanic rocks, presumably in search of copper-nickel mineralization.

GOLD STANDARD MINING CO.

Napanee Lake

The Gold Standard Mining Co. (Figure 7, Property 5) was actively exploring for gold in the map area from 1900 through 1902 (Carter 1901, 1904). In 1900, underground exploration was carried out in a 2.4 m wide quartz vein west of Sairey Gamp Lake (Table 9; Carter 1901). There are no reports of gold values encountered during the operation and the shaft was not located by the field crew. A map prepared by Lawson (1887) indicates that Sairey Gamp Lake was the former name of Napanee Lake.

The geology of this area is discussed further under the Sairey Gamp occurrence (Figure 7, Property 9).

Neilson Lake

In 1902, following work that had taken place west of Sairey Gamp Lake, the Gold Standard Mining Co. (Figure 7, Property 6) explored a quartz vein on Neilson Lake via shaft sinking and drifting in 1902 (Table 9; Carter 1904). Thomson (1934) reported a value of 1.8 ounces Au per ton from selected material on the dump. The author's sample of pyritic and chalcopyritic quartz vein material from the dump returned 1.37 ounces Au per ton (Table 8, sample 0084).

The shaft was sunk on a 1.8 m wide quartz vein within a northeast-striking shear zone that is only slightly wider than the vein. The surrounding rock is predominantly intermediate, massive and pillowed flows, minor phaneritic basalt flows and intermediate pyroclastics. A north-striking quartz-feldspar porphyry dike intrudes the metavolcanic rocks 50 m north of the shaft. The quartz vein extends for approximately 20 to 25 m to the northeast, to Neilson Lake. At this point, the vein is contorted, possibly boudinaged and terminated. It was not located in the underground workings (Carter 1904) and it appears that the vein is podiform. A 5 to 8 cm alteration halo surrounds the vein, and consists mainly of iron-carbonate, sericite and trace quantities of sulphide mineralization and green mica.

Gold and silver mineralization appear to be localized within sulphides (Table 8, sample 0084,) which are erratically distributed and are less than 5% of the veins, on average. Sulphide-barren quartz, and the altered wall rock, contain only slightly elevated gold values (Table 8, samples 0085, 0086).

The shear zone which hosts the quartz vein appears to extend southeast to Napanee Lake; however, due to the narrow width and the apparent podiform nature of quartz veins within the shear zone, gold exploration along this horizon may be difficult.

JALNA RESOURCES LTD. (1985)

From 1983 through 1985, Jalna Resources Ltd. (Figure 7, Property 7) held a large group of claims located along the northeast shore of Lower Manitou Lake and extending from Aronson Lake to Mosher Bay, northeast of the map area. Reconnaissance litho-geochemistry followed by grid-line soil and rock-chip geochemistry delineated a zone of anomalous gold values extending 335 m northeast from the shore of Aronson Lake. A trenching and stripping program uncovered a 0.75 m wide zone of pyritic chert which yielded up to 350 ppb gold, 1724 ppm zinc,751 ppm copper, 16 ppm antimony and 933 ppm arsenic. Jalna Resources Ltd. indicated that arsenic accompanies gold mineralization and is the best "pathfinder" element for geochemical exploration in this area. The gold zone along the north shore of Aronson Lake was examined and sampled by the author. The results, with the exception of antimony (Table 8, samples 0003 and 0004), correlate well with those obtained by Jalna Resources Ltd.

The area of interest is underlain by laminated chert and bedded intermediate tuff of the Etta Lake forma-

tion, which are in contact with plagioclase-phyric basalt flows of the Wapageisi Lake group (Blackburn 1976, 1982). Bedding and contacts generally strike 030° and stratigraphy youngs to the northwest. Narrow, pyritic shear zones, up to 50 cm wide and striking 062° to 085°, cut the rocks and are the preferred host for gold mineralization. A late-stage north-striking fault sinistrally offsets and rotates the rocks located west of the showing (Ontario Geological Survey 1980), but its effect on the mineralization is unknown. This environment occurs elsewhere in the northeastern part of the map area and it is a favourable target for gold exploration.

NORANDA EXPLORATION COMPANY, LIMITED

Noranda Exploration Company, Limited (Figure 7, Property 8) explored various parts of the map area at various times from 1973 through 1988.

In 1973, a search for base metal mineralization resulted in 4 unpatented mining claims being staked over an airborne electromagnetic anomaly located southeast of Kahabeness Lake. Ground electromagnetic, magnetic and geological surveys were carried out by Noranda; however, the signal strength of the ground conductor was considered to be insufficient to warrant further attention and the claims were allowed to lapse.

Underlying the claim group is the contact between the granodiorite of the Irene–Eltrut Lakes complex and the mafic pillowed flows and porphyritic gabbro of the Wapageisi Lake group. Silver-gold mineralization occurs in the Fahey–Graves lakes area to the southwest.There is no history of base metal mineralization in this area (Smith 1990; Smith and Stephenson 1988).

In 1984, 47 unpatented mining claims were staked in an area located approximately 1500 m west of Gates Lake and extending south of the map area. Lithogeochemical and geological surveys were carried out along the claim lines and this was followed by a ground magnetometer survey and an induced polarization survey over 2 of the claims.

Geochemical results gave no gold values over 10 ppb and mercury in the range of 5 ppb to 180 ppb. The geophysical surveys failed to detect any mineralization and the claims were subsequently allowed to lapse.

Calc-alkalic metavolcanic massive flows and pillowed flows with minor pyroclastic deposits underlie most of the area. Subordinate rock types include quartz-feldspar porphyry, related extrusive rocks and gabbro. The claim group covered the Austin antimony occurrence and readers are referred to Smith and Stephenson (1988) and Smith (1990) for further details. Sample 0257 (Table 8) was collected by the author in this area,from a 1 m wide, northeast-striking shear zone that contained considerable rusty material with very little pyrite.

In 1988, Noranda Exploration Company, Limited restaked a large block of claims that extended from the west end of Gates Lake to west of the map area. Airborne VLF-EM and magnetic surveys were flown and filed for assessment work credit (Assessment Files Research Office, Ontario Geological Survey). As of January 1989, the claims were still in good standing.

The airborne surveys were used by the author as an aid to interpreting the distribution of geological units and location of significant structures in this part of the map area.

SAIREY GAMP OCCURRENCE

Carter (1901) reported that work on the Sairey Gamp occurrence (Figure 7, Property 9) consisted of a shaft and crosscut on a wide quartz vein on the north side of Sairey Gamp Lake (Napanee Lake). Gold values were not reported and the workings were abandoned in 1902.

A shaft, presumed to be the Sairey Gamp occurrence, was located by the field crew on the north shore of Napanee Lake. The shaft was sunk on a quartz vein of undetermined width. The vein is hosted by altered calc-alkalic metavolcanic rocks in an east-northeast-striking shear zone approximately 3 m wide. Three samples were collected from the dump material and analyses detected no anomalous mineralization (Table 8, samples 0067, 0068, 0069).

The quartz vein material contains abundant iron carbonate but little sulphide mineralization. The wall rock from the dump is predominantly chlorite schist containing abundant iron carbonate, sericite and trace amounts of cubic pyrite. The shoreline is heavily overgrown and consequently the shear zone and quartz vein could not be traced for more than 20 m. Approximately 300 m to the southwest, sheared pyroxenite is present; it appears to be the along-strike extension of the shear zone. Sheared calc-alkalic flows and pyroclastic rocks occur along strike to the northeast and the shear zone possibly extends to the Gold Standard occurrence on Neilson Lake. The other Gold Standard occurrence is supposedly located west of the Sairey Gamp occurrence (Carter 1901). Further exploration is warranted in this entire area.

SILVER LAKE RESOURCES INC.

From 1984 through 1986, Silver Lake Resources Inc. (Figure 7, Property 10) held 161 unpatented mining claims extending from Eyelid Lake to Syndicate Lake. Ground magnetometer and VLF-EM surveys were followed by geological and soil geochemical surveys. A rock-chip lithogeochemical survey was carried out in conjunction with the geological survey (Table 9). The geophysical surveys were carried out to delineate geological contacts and zones of possible mineralization.

Of the 70 rock samples submitted for gold analyses by Silver Lake Resources Inc., 5 returned greater than trace amounts of gold with a high of 0.014 ounce Au per ton (470 ppb). The soil geochemistry outlined 4 possible gold anomalies with a maximum value of 85 ppb gold; Silver Lake Resources estimated the background to be 4 ppb). Although these values are not economical, their distribution displays interesting patterns that are described below.

The highest rock-assay value came from sheared intermediate metavolcanic rocks within the Pipestone–Cameron–Manitou deformation zone northeast of Phairs Lake. Shoreline traverses carried out by the field crew in this area detected numerous zones containing pyrite, sericite, tourmaline and quartz veins within a broad iron-carbonate alteration halo. Although the alteration is generally favourable for gold mineralization, selected samples did not return values above 28 ppb Au (Table 8, samples 0232 to 0239). The highest gold values found in the soil occurred between Calder Lake and Syndicate Lake; they are spatially associated with a VLF-EM conductor. This area is underlain by felsic to intermediate pyroclastic deposits that commonly contain fragments bearing green mica. It is probable that a north-striking fault cuts the rocks in this area and thus makes a prospective exploration target.

SPARTON RESOURCES INC.

In 1983, Sparton Resources Inc. (Figure 7, Property 11) staked 298 unpatented mining claims in 3 groups of claims throughout the region. The largest of these groups consisted of 239 claims and extended from Mister Lake to Straw Lake, located west of the map area. Ground magnetometer and VLF-EM surveys were carried out, together with detailed prospecting over the Mister Lake portion of this claim group. Several VLF-EM conductors were located; they were assigned priorities based on the strength of the response and the correlation with magnetic anomalies. The prospecting survey concentrated on sampling and assaying mineralized outcrops and float for gold. Several samples from the Mister Lake area returned up to 60 ppb gold, when assayed. No further work was reported from this area and the claims were allowed to lapse.

A second group of 39 claims was staked, by Sparton Resources Inc., to cover a gold showing in the Hailstone Bay (local name)–Manitou Stretch area located along the southern boundary of the map area. A minimum amount of work was carried out in the map area and readers are referred to Smith (1990) for details of the work program.

Sparton Resources' third claim group comprised 20 unpatented mining claims. These claims were staked in the Peep Bay area of Manitou Stretch to cover the gold showings explored by Birch Bay Gold Mines, Limited in the 1940s (Figure 7, Property 1). At the time, Birch Bay Gold Mines, Limited explored several separate quartz veins and mineralized zones by surface trenching. Visible gold was reported to occur in one 10 cm wide quartz vein. Up to 0.08 ounce Au per ton over 3 m was reported from a north-striking schist zone, and up to 0.1 ounce Au per ton over 5.1 m was reported from an arsenopyrite-bearing zone. These values were considered uneconomic by the operators at the time and no further work was carried out (Resident Geologist's office, Kenora).

Work carried out by Sparton Resources Inc. on its group of claims included ground VLF-EM and magnetic surveys, a soil geochemistry survey and a geological survey. The old trenches sunk by Birch Bay Gold Mines, Limited were cleaned and sampled in detail. Two diamond-drill holes tested for mineralization under 2 of the old trenches.

The best results from the sampling of the trenches by Sparton Resources are reported in Table 9. Several other assays in the range of 0.02 to 0.10 ounce Au per ton were also encountered. The diamond-drill holes failed to intersect sub-surface mineralization and no values greater than 150 ppb gold were returned. Following the diamond drilling, no further work was carried out and the claims were allowed to lapse.

The Peep Bay gold showings lie within a structurally complex portion of the Pipestone–Cameron–Manitou deformation zone. Numerous northeast-striking shear zones 3 to 20 m wide are predominant and locally display sinistral rotation of an east-northeasterly striking fabric. North-striking shear zones and faults transect these earlier structures in several places. Gold mineralization appears to be associated with each of these structural elements (Resident Geologist's office, Kenora).

During the field season, the Peep Bay area was mapped by the author and several of the trenches that had been cleaned by Sparton Resources Inc. were located (Figure 9). Samples were collected from some of these trenches and the results are presented in Table 8.

Figure 10 shows the distribution of mineralization and alteration in trench 1, located along the west shore of Peep Bay. Gold is strongly associated with high arsenic and total sulphide content and to a lesser extent, with pervasive silicification developed along the northeast-striking fabric. The host rock is iron-carbonate-altered leucocratic gabbro to mafic schist and occurs in a geological setting similar to the Gates Lake occurrence (*see* "Birch Bay Gold Mines, Limited").

In trench 4 (*see* Figure 9), located approximately 300 m to the southwest of trench 1, gold is associated with pyrite and arsenopyrite in a silicified and albitized zone up to 5 m wide. Here, the mineralization has an east-northeasterly strike and appears to be localized in tension fractures within an iron-carbonatized gabbro. Gold tenor appears to be higher in this zone than in trench 1 and thus appears to have better economic potential (Table 8, sample 0207; Table 9, Sparton Resources Inc. assays). This trench is correlated with the arsenopyrite-bearing zone described by Birch Bay Gold Mines (Resident Geologist's office, Kenora).

Quartz veins and a quartz stockwork, accompanied by pyrite and arsenopyrite, are exposed in trenches 5 and 6 (*see* Figure 9), located approximately 100 m west of Peep Bay. The host rock is a sheared, intermediate, amygdaloidal flow that exhibits pervasive iron-carbonate and sericite alteration. Sparton Resources Inc. reported 0.15 ounce Au per ton and 1.4 ounces Ag per ton over 2 m from this zone (Table 9); however, sampling of trench 5 by the author did not encounter promising gold values (Table 8, samples 0229, 0230).

About 100 m southwest of trench 5, a northeast-striking quartz vein, 30 to 40 cm wide, in sheared inter-

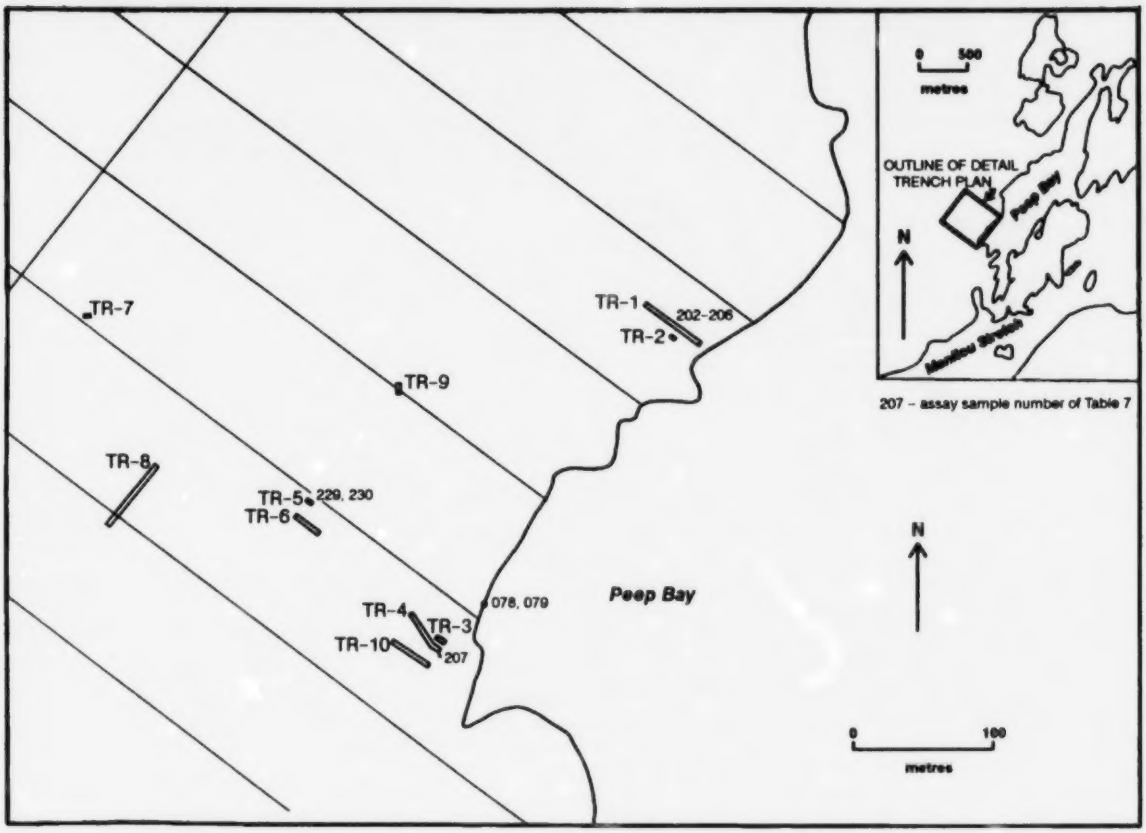

Figure 9. Trench location map, Peep Bay gold showings;. modified after Sparton Resources Inc., 1985.

mediate pillow breccia is exposed in trench 8 (*see* Figure 9). The vein is sulphide barren and the wall rock contains minor iron-carbonate, sericite and trace sulphide mineralization. Sparton Resources Inc. reported gold assays that had no greater than 0.03 ounce Au per ton and, in general, all the quartz veins in intermediate fragmental rocks contained low gold values (Assessment Files Research Office, Ontario Geological Survey).

North-striking shear zones and faults transect all rock units and earlier structures at Peep Bay. Where observed by the author, these structures are generally narrow, 1 m to 3 m, and are devoid of mineralization and alteration. However, one report indicates that a north-striking shear zone in the Peep Bay area returned 0.08 ounce Au per ton over ten feet (Birch Bay Gold Mines, Limited, assessment files, Resident Geologist's office, Kenora). This suggests that these structures may be economically important and should not be ignored.

These data indicate that structurally competent rock units in the Peep Bay area, such as gabbro and massive flows, are preferred hosts for gold mineralization as compared to pyroclastic and pillow breccia units. The gabbro is a particularly favourable unit as gold mineralization is associated with similar rocks at Gates Lake and the Gaffney deposit located northeast of the map area. Future exploration at Peep Bay should concentrate on looking for silicified zones in east-northeast-striking tension fractures within the gabbro.

TECK CORPORATION

In 1982, Teck Corporation was actively exploring the Gaffney gold occurrence on Manitou Island, located approximately 6 km northeast of the map area. As a result of this activity, several companies staked mining claims within the map area and subsequently optioned them to Teck Corporation (Figure 7, Property 12). These companies included S.O. Resources Inc., Youngman Oil & Gas Ltd. and Wildcat Petroleum Ltd. On each of these properties, ground magnetometer and VLF-EM surveys were carried out and readers are referred to Table 9 for property locations and significant results. No further work was reported and all claims were allowed to lapse.

VAN ENK, REIN

In 1983, Rein Van Enk (Figure 7, Property 13) of Norontex Exploration Limited staked fourteen unpatented mining claims to cover the Gates Lake showing. A summary report was filed for assessment work credit and

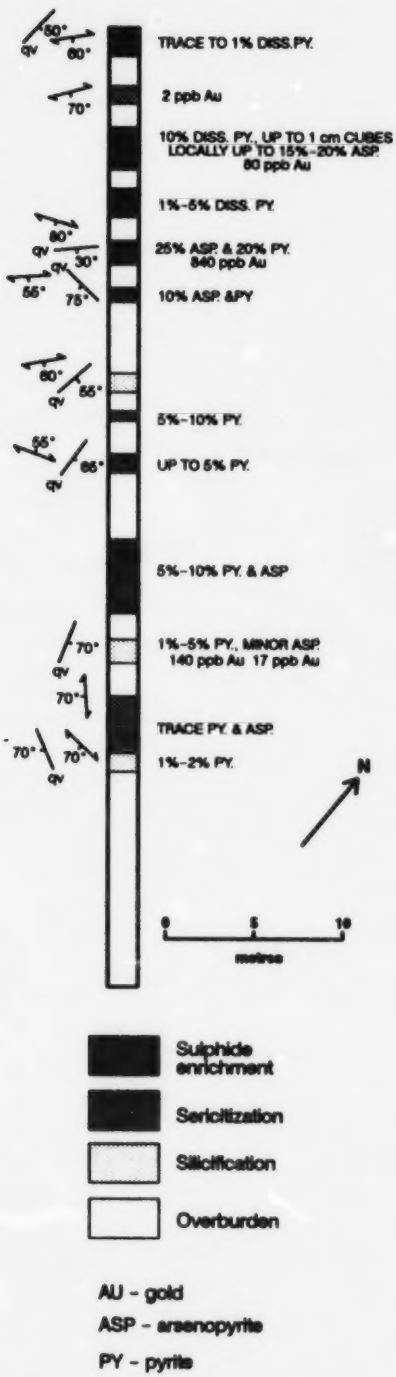

Figure 10. Sparton Resources Inc. trench 1, Peep Bay. The host rock is a pervasively carbonatized mafic metavolcanic flow to gabbroic intrusive rock.

most of the details are covered in the Birch Bay Gold Mines, Limited section.

RECOMMENDATIONS TO PROSPECTORS

Gold occurs in 3 structurally controlled environments in the map area. Gold, accompanied by pyrite and arsenopyrite, occurs in carbonatized and silicified shears and fractures within the Pipestone–Cameron–Manitou deformation zone at Gates Lake and Peep Bay. Gabbro is the preferred host in both areas; however, any structurally competent rock unit may host gold mineralization. The Pipestone–Cameron–Manitou deformation zone is a regionally extensive structure and is known to host gold deposits at Cameron Lake, Straw Lake, Manitou Island and Goldrock on Upper Manitou Lake. Therefore this structure is economically important and a prime exploration target within the map area.

Gold occurs in narrow shear zones parallel to, but outside of, the Pipestone–Cameron–Manitou deformation zone and within narrow shear zones in metavolcanic rocks near the contacts with the granitic batholiths. The Gold Standard occurrence at Neilson Lake and the Sairey Gamp occurrence at Napanee Lake occur in northeast- striking shear zones that are parallel to the major deformation zone. The 2 occurrences are possibly connected by the same structure, which indicates that the intervening ground between Neilson and Napanee Lakes warrants further exploration. Quartz veining, pervasive iron-carbonate alteration and northeast-striking shearing occurs southwest of Davis Lake, which suggests that this area warrants further exploration.

South of Kahabeness Lake, several narrow shear zones in amphibolitized mafic metavolcanic rocks host quartz pods and/or rusty concentrations of sulphide minerals. Samples collected by the field crew show presence of gold and copper enrichment in these zones (Table 8, samples 0171, 0172). Considering the proximity of these samples to known gold-silver-molybdenum mineralization south of the map area at Vickers Lake, the Kahabeness Lake area warrants further exploration (Smith, 1990; Smith and Stephenson 1988).

Geochemically anomalous gold, arsenic, copper and zinc occur within units of the Etta Lake formation (Blackburn 1982) at Aronson Lake and along the northern part of Manitou Stretch (Table 8, samples 0003, 0004, 0255, 0258). Mineralization is localized in sheared and pyritic cherty metasediments and intermediate metavolcanic rocks located near the intersection with north-striking faults. Although economic gold values have yet to be encountered, this environment is worthy of further exploration.

Previous base metal exploration has been cursory in the author's opinion and geological mapping indicates that there are 2 untested areas with base metal potential. The felsic to intermediate metavolcanic rocks underlying the Calder Lake–Syndicate Lake area are composed of pyroclastic and epiclastic deposits, commonly with fragments containing green mica. Possible block and ash pyroclastic units and ash flow deposits indicate a proximal depositional environment favourable for base metal deposition. Any airborne bedrock electromagnet-

have yet to be encountered, this environment is worthy of further exploration.

Previous base metal exploration has been cursory in the author's opinion and geological mapping indicates that there are 2 untested areas with base metal potential. The felsic to intermediate metavolcanic rocks underlying the Calder Lake–Syndicate Lake area are composed of pyroclastic and epiclastic deposits, commonly with fragments containing green mica. Possible block and ash pyroclastic units and ash flow deposits indicate a proximal depositional environment favourable for base metal deposition. Any airborne bedrock electromagnetic anomaly or moderate to strong ground electromagnetic conductor would warrant testing in this environment.

The second untested area is the large silicified area at Harris Lake (*see* "Alteration"; Photo 8). Disseminated sulphide mineralization is widely distributed around the periphery of the silicified area, with the greatest concentration observed along the north shore of Harris Lake. A few samples collected by the field crew failed to disclose any anomalous mineralization; however, sampling of this area is incomplete as much of the area lies under Harris Lake (Table 8, samples 0275, 0278, 0314, 0317, 0331). In this environment, any bedrock electromagnetic conductor would merit further exploration.

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CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

MAPS
NOT
FILMED

CARTES
OMISES